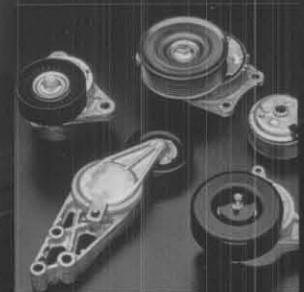
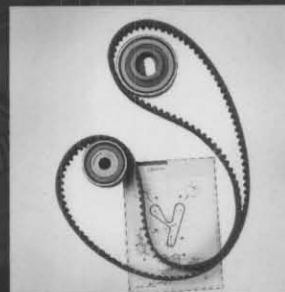
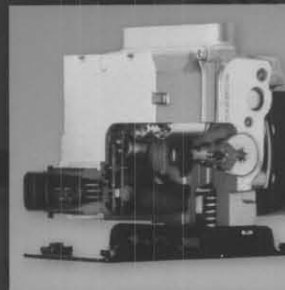


PARTS SPECIALIST SERIES

P2 Automobile



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Taking An ASE Certification Test



This study guide will help prepare you to take and pass the ASE test. It contains descriptions of the types of questions used on the test, the task list from which the test questions are derived, a review of the task list subject information, and a practice test containing ASE style questions.

ABOUT ASE

The National Institute for Automotive Service Excellence (ASE) is a non-profit organization founded in 1972 for the purpose of improving the quality of automotive service and repair through the voluntary testing and certification of automotive technicians. Currently, there are over 400,000 professional technicians certified by ASE in over 40 different specialist areas.

ASE certification recognizes your knowledge and experience, and since it is voluntary, taking

and passing an ASE certification test also demonstrates to employers and customers your commitment to your profession. It can mean better compensation and increased employment opportunities as well.

ASE not only certifies technician competency, it also promotes the benefits of technician certification to the motoring public. Repair shops that employ at least one ASE technician can display the ASE sign. Establishments where 75 percent of technicians are certified, with at least one technician certified in each area of service offered by the business, are eligible for the ASE Blue Seal of Excellence program. ASE encourages consumers to patronize these shops through media campaigns and car care clinics.

To become ASE certified, you must pass at least one ASE exam and have at least two years of related work experience. Technicians

that pass specified tests in a series earn Master Technician status. Your certification is valid for five years, after which time you must retest to retain certification, demonstrating that you have kept up with the changing technology in the field.

THE ASE TEST

An ASE test consists of forty to eighty multiple-choice questions. Test questions are written by a panel of technical experts from vehicle, parts and equipment manufacturers, as well as working technicians and technical education instructors. All questions have been pre-tested and quality checked on a national sample of technicians. The questions are derived from information presented in the task list, which details the knowledge that a technician must have to pass an ASE test and be recognized as

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Customer Service 1-800-240-1968

FAX 218-740-6437

e-mail: PassTheASE@advanstar.com

URL: www.PassTheASE.com

P2 - AUTOMOBILE PARTS SPECIALIST

competent in that category. The task list is periodically updated by ASE in response to changes in vehicle technology and repair techniques.

There are five types of questions on an ASE test:

- **Direct, or Completion**
- **MOST Likely**
- **Technician A and Technician B**
- **EXCEPT**
- **LEAST Likely**

Direct, or Completion

This type of question is the kind that is most familiar to anyone who has taken a multiple-choice test: you must answer a direct question or complete a statement with the correct answer. There are four choices given as potential answers, but only one is correct. Sometimes the correct answer to one of these questions is clear, however in other cases more than one answer may seem to be correct. In that case, read the question carefully and choose the answer that is most correct. Here is an example of this type of test question:

A compression test shows that one cylinder is too low. A leakage test on that cylinder shows that there is excessive leakage. During the test, air could be heard coming from the tailpipe. Which of the following could be the cause?

- A. broken piston rings
- B. bad head gasket
- C. bad exhaust gasket
- D. an exhaust valve not seating

There is only one correct answer to this question, answer D. If an exhaust valve is not seated, air will leak from the combustion chamber by way of the valve out to the tailpipe and make an audible sound. Answer C is wrong because an exhaust gasket has nothing to do with combustion chamber seal-

ing. Answers A and B are wrong because broken rings or a bad head gasket would have air leaking through the oil filler or coolant system.

MOST Likely

This type of question is similar to a direct question but it can be more challenging because all or some of the answers may be nearly correct. However, only one answer is the most correct. For example:

When a cylinder head with an overhead camshaft is discovered to be warped, which of the following is the most correct repair option?

- A. replace the head
- B. check for cracks, straighten the head, surface the head
- C. surface the head, then straighten it
- D. straighten the head, surface the head, check for cracks

The most correct answer is B. It makes no sense to perform repairs on a cylinder head that might not be usable. The head should first be checked for warpage and cracks. Therefore, answer B is more correct than answer D. The head could certainly be replaced, but the cost factor may be prohibitive and availability may be limited, so answer B is more correct than answer A. If the top of the head is warped enough to interfere with cam bore alignment and/or restrict free movement of the camshaft, the head must be straightened before it is resurfaced, so answer C is wrong.

Technician A and Technician B

These questions are the kind most commonly associated with the ASE test. With these questions you are asked to choose which technician statement is correct, or whether they both are correct or incorrect. This type of question can be difficult because very often

you may find one technician's statement to be clearly correct or incorrect while the other may not be so obvious. Do you choose one technician or both? The key to answering these questions is to carefully examine each technician's statement independently and judge it on its own merit. Here is an example of this type of question:

A vehicle equipped with rack-and-pinion steering is having the front end inspected. Technician A says that the inner tie rod ends should be inspected while in their normal running position. Technician B says that if movement is felt between the tie rod stud and the socket while the tire is moved in and out, the inner tie rod should be replaced. Who is correct?

- A. Technician A
- B. Technician B
- C. Both A and B
- D. Neither A or B

The correct answer is C; both technicians' statements are correct. Technician B is clearly correct because any play felt between the tie-rod stud and the socket while the tire is moved in and out indicates that the assembly is worn and requires replacement. However, Technician A is also correct because inner tie- rods should be inspected while in their normal running position, to prevent binding that may occur when the suspension is allowed to hang free.

EXCEPT

This kind of question is sometimes called a negative question because you are asked to give the incorrect answer. All of the possible answers given are correct EXCEPT one. In effect, the correct answer to the question is the one that is wrong. The word EXCEPT is always capitalized in these questions. For example:

All of the following are true of torsion bars **EXCEPT**:

- A. They can be mounted longitudinally or transversely.
- B. They serve the same function as coil springs.
- C. They are interchangeable from side-to-side
- D. They can be used to adjust vehicle ride height.

The correct answer is C. Torsion bars are not normally interchangeable from side-to-side. This is because the direction of the twisting or torsion is not the same on the left and right sides. All of the other answers contain true statements regarding torsion bars.

LEAST Likely

This type of question is similar to **EXCEPT** in that once again you are asked to give the answer that is wrong. For example:

Blue-gray smoke comes from the exhaust of a vehicle during deceleration. Of the following, which cause is **LEAST** likely?

- A. worn valve guides
- B. broken valve seals
- C. worn piston rings
- D. clogged oil return passages

The correct answer is C. Worn piston rings will usually make an engine smoke worse under acceleration. All of the other causes can allow oil to be drawn through the valve guides under the high intake vacuum that occurs during deceleration.

PREPARING FOR THE ASE TEST

Begin preparing for the test by reading the task list. The task list describes the actual work performed by a technician in a particular specialty area. Each question on an ASE test is derived from a task or set of tasks in the list. Fa-

miliarizing yourself with the task list will help you to concentrate on the areas where you need to study.

The text section of this study guide contains information pertaining to each of the tasks in the task list. Reviewing this information will prepare you to take the practice test.

Take the practice test and compare your answers with the correct answer explanations. If you get an answer wrong and don't understand why, go back and read the information pertaining to that question in the text.

After reviewing the tasks and the subject information and taking the practice test, you should be prepared to take the ASE test or be aware of areas where further study is needed. When studying with this study guide or any other source of information, use the following guidelines to make sure the time spent is as productive as possible:

- **Concentrate on the subject areas where you are weakest.**
- **Arrange your schedule to allow specific times for studying.**
- **Study in an area where you will not be distracted.**
- **Don't try to study after a full meal or when you are tired.**
- **Don't wait until the last minute and try to 'cram' for the test.**

REGISTERING FOR ASE COMPUTER-BASED TESTING

Registration for the ASE CBT tests can be done online in myASE or over the phone. While not mandatory, it is recommended that you establish a myASE account on the ASE website (www.ase.com). This can be a big help in managing the ASE certification process, as your test scores and certification expiry dates are all listed there.

Test times are available during two-month windows with a one-month break in between. This means that there is a total of eight months over the period of the calendar year that ASE testing is available.

Testing can be scheduled during the daytime, night, and weekends for maximum flexibility. Also, results are available immediately after test completion. Printed certificates are mailed at the end of the two-month test window. If you fail a test, you will not be allowed to register for the same test until the next two-month test window.

TAKING THE ASE TEST - COMPUTER-BASED TESTING (CBT)

On test day, bring some form of photo identification with you and be sure to arrive at the test center 30 minutes early to give sufficient time to check in. Once you have checked in, the test supervisor will issue you some scratch paper and pencils, as well as a composite vehicle test booklet if you are taking advanced tests. You will then be seated at a computer station and given a short online tutorial on how to complete the ASE CBT tests. You may skip the tutorial if you are already familiar with the CBT process.

The test question format is similar to those found in written ASE tests. Regular certification tests have a time limit of 1 to 2 hours, depending on the test. Recertification tests are 30 to 45 minutes, and the L1 and L2 advanced level tests are capped at 2 hours. The time remaining for your test is displayed on the top left of the test window. You are given a warning when you have 5 minutes left to complete the test.

Read through each question carefully. If you don't know the answer to a question and need to

think about it, click on the "Flag" button and move on to the next question. You may also go back to previous questions by pressing the "Previous Question" button. Don't spend too much time on any one question. After you have worked through to the end of the test, check your remaining time and go back and answer the questions you flagged. Very often, information found in questions later in the test can help answer some of the ones with which you had difficulty.

Some questions may have more content than what can fit on one screen. If this is the case, there will be a "More" button displayed where the "Next Question" button would ordinarily appear. A scrolling bar will also appear, showing what part of the question you are currently viewing. Once you have viewed all of the related content for the question, the "Next Question" button will reappear.

You can change answers on

any of the questions before submitting the test for scoring. At the end of the examination, you will be shown a table with all of the question numbers. This table will show which questions are answered, which are unanswered, and which have been flagged for review. You will be given the option to review all the questions, review the flagged questions, or review the unanswered questions from this page. This table can be reviewed at any time during the exam by clicking the "Review" button.

If you are running out of time and still have unanswered test questions, guess the answers if necessary to make sure every question is answered. Do not leave any answers blank. It is to your advantage to answer every question, because your test score is based on the number of correct answers. A guessed answer could be correct, but a blank answer can never be.

Once you are satisfied that all

of the questions are complete and ready for scoring, click the "Submit for Scoring" button. If you are scheduled for more than one test, the next test will begin immediately. If you are done with testing, you will be asked to complete a short survey regarding the CBT test experience. As you are leaving the test center, your supervisor will give you a copy of your test results. Your scores will also be available on myASE within two business days.

To learn exactly where and when the ASE Certification Tests are available in your area, as well as the costs involved in becoming ASE certified, please contact ASE directly for registration information.

The National Institute for Automotive Service Excellence
101 Blue Seal Drive, S.E. Suite 101
Leesburg, VA 20175
1-800-390-6789
<http://www.ase.com>

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Automobile Parts Specialist

TEST SPECIFICATIONS FOR AUTOMOBILE PARTS SPECIALIST (TEST P2)



CONTENT AREA	NUMBER OF QUESTIONS IN ASE TEST	PERCENTAGE OF COVERAGE IN ASE TEST
A. General Operations	10	13%
B. Customer Relations And Sales Skills	11	15%
C. Vehicle Systems Knowledge	40	53%
1. Engine Mechanical Parts	(3)	
2. Cooling Systems	(2)	
3. Fuel Systems	(3)	
4. Ignition Systems	(3)	
5. Exhaust Systems	(2)	
6. Emissions Control Systems	(3)	
7. Manual Transmission/Transaxle	(2)	
8. Automatic Transmission/Transaxle	(2)	
9. Drivetrain Components	(2)	
10. Brakes	(3)	
11. Suspension And Steering	(3)	
12. Heating And Air Conditioning	(3)	
13. Electrical/Electronic Systems	(3)	
14. Battery, Charging And Starting Systems	(3)	
15. Miscellaneous	(3)	
D. Vehicle Identification	3	4%
E. Cataloging Skills	6	8%
F. Inventory Management	3	4%
G. Merchandising	2	3%
Total	75	100%

The test could contain up to ten additional questions that are included for statistical research purposes only. Your answers to these questions will not affect your score, but since you do not know which ones they are, you should answer all questions in the test.

The 5-year Recertification Test will cover the same content areas as those listed above. However, the number of questions in each content area of the Recertification Test

will be reduced by about one-half.

The following pages list the tasks covered in each content area. These task descriptions offer detailed information to parts specialists preparing for the test, and to persons who may be instructing parts specialists. The task list may also serve as a guideline for question writers, reviewers and test assemblers.

It should be noted that the number of questions in each content

area may not equal the number of tasks listed. Some of the tasks are complex and broad in scope, and may be covered by several questions. Other tasks are simple and narrow in scope; one question may cover several tasks. The main purpose for listing the tasks is to describe accurately what is done on the job, not to make each task correspond to a particular test question.

AUTOMOBILE PARTS SPECIALIST TEST TASK LIST

A. GENERAL OPERATIONS (10 questions)

Task 1 - Calculate discounts, selling prices, percentages, and pro-rated warranties.

Task 2 - Determine the need for special orders and/or handling charges.

Task 3 - Identify and convert units of measure.

Task 4 - Determine alphanumeric sequences.

Task 5 - Determine sizes with precision measuring tools and equipment.

Task 6 - Perform money transactions (cash, checks, credit and debit cards).

Task 7 - Perform sales and credit invoicing.

Task 8 - Interact with management and fellow employees.

Task 9 - Know the value of housekeeping skills (facility, work stations and backroom).

Task 10 - Assist with employee and customer training.

Task 11 - Identify potential safety risks; demonstrate proper safety practices.

Task 12 - Identify proper handling of regulated and/or hazardous materials.

Task 13 - Identify potential security risks.

Task 14 - Identify parts industry terminology.

Task 15 - Know the value of company policies and procedures.

Task 16 - Know the basic functions of tools and equipment used in automotive service.

B. CUSTOMER RELATIONS AND SALES SKILLS

(11 questions)

Task 1 - Identify customer needs and skill level.

Task 2 - Handle customer complaints.

Task 3 - Provide information related to the sale, and warranty return policy.

Task 4 - Handle the return of products; determine the difference between new, core, warranty, labor claim and customer satisfaction returns.

Task 5 - Acknowledge/greet customer.

Task 6 - Demonstrate proper telephone skills.

Task 7 - Obtain pertinent product application information.

Task 8 - Present a knowledgeable and professional business image.

Task 9 - Recognize the importance of selling related items.

Task 10 - Identify product features and benefits.

Task 11 - Handle sales objections.

Task 12 - Balance telephone and in-store customers.

Task 13 - Promote store services and features.

Task 14 - Promote premium products.

Task 15 - Solve customer problems.

Task 16 - Close the sale.

C. VEHICLE SYSTEMS KNOWLEDGE

(40 questions)

1. Engine Mechanical Parts

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

2. Cooling Systems

(2 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

3. Fuel Systems

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

4. Ignition Systems

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

5. Exhaust Systems

(2 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

6. Emissions Control Systems

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

7. Manual Transmission/ Transaxle

(2 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify basic related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

**8. Automatic Transmission/
Transaxle**

(2 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

**9. Drivetrain Components
(Includes Driveshafts,
Halfshafts, U-joints,
CV-joints, And Four-Wheel
Drive Systems)**

(2 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

10. Brakes

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

11. Suspension And Steering

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

**12. Heating And Air
Conditioning**

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

**13. Electrical/Electronic
Systems**

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

**14. Battery, Charging And
Starting Systems**

(3 questions)

Task 1 - Identify major components.

Task 2 - Identify component function and common reasons for replacement.

Task 3 - Identify related items.

Task 4 - Provide basic use, maintenance, installation and warranty information.

Task 5 - Conduct basic battery tests.

15. Miscellaneous

(3 questions)

Task 1 - Identify fastener thread types (SAE, USS and metric).

Task 2 - Identify fastener thread diameter, pitch and length.

Task 3 - Identify fastener type.

Task 4 - Identify fastener grade.

Task 5 - Identify fitting type.

Task 6 - Identify fitting sizes.

Task 7 - Identify basic body repair and refinishing materials and supplies.

Task 8 - Identify hose and tubing types and applications.

Task 9 - Determine hose and tubing size.

Task 10 - Recommend proper application and usage of chemicals and appearance products.

Task 11 - Recommend proper application and usage of vision and safety products.

Task 12 - Identify special application belts.

Task 13 - Recommend proper application and usage of after-market accessories.

D. VEHICLE IDENTIFICATION

(3 questions)

Task 1 - Locate and utilize vehicle ID number (VIN).

Task 2 - Locate production date.

Task 3 - Locate and utilize component identification data and vehicle specific build options.

Task 4 - Identify body styles and chassis configurations.

Task 5 - Utilize additional reference material for interpreting component information.

Task 6 - Locate paint code(s).

E. CATALOGING SKILLS

(6 questions)

Task 1 - Locate proper catalog and identify needed part(s).

Task 2 - Obtain and interpret additional information (foot-note, illustration, etc.).

Task 3 - Utilize additional reference material (technical bulletins, interchange list, supplements, specification guides, internet sites, etc.).

Task 4 - Identify catalog terminology and abbreviations.

Task 5 - Locate index and table of contents.

Task 6 - Perform catalog maintenance.

F. INVENTORY MANAGEMENT

(3 questions)

Task 1 - Report lost sales.

Task 2 - Verify incoming and outgoing merchandise.

Task 3 - Know the reasons for performing a physical inventory.

Task 4 - Identify the cause of, and report inventory discrepancies.

Task 5 - Know the reasons for, and perform stock rotation.

Task 6 - Handle special orders and outside purchases.

Task 7 - Perform proper core handling (i.e.,: accepting or declining cores, storage and return).

Task 8 - Handle and document warranty and new returns.

Task 9 - Determine proper order/selling unit (each, pair, case, etc.) increment.

Task 10 - Handle return of broken kits, special order parts and exchange parts.

Task 11 - Account for store use items.

Task 12 - Understand the concept of inventory turnover and its affect on profitability.

G. MERCHANDISING

(2 questions)

Task 1 - Understand display strategy.

Task 2 - Price display products.

Task 3 - Inspect and maintain shelf quantities and condition.

Task 4 - Identify impulse, seasonal and related items.

Task 5 - Utilize sales aides.

The preceding Task List data details all of the related informational subject matter you are expected to know in order to sit for this ASE Certification Test. Your own years of experience in professional automotive parts sales also should provide you with added background.

Finally, a conscientious review of the self-study material provided in this Training for ASE Certification unit also should help you to be adequately prepared to take this test.



General Operations

PROFITS, DISCOUNTS, PERCENTAGES AND PRO-RATES

As an automotive parts specialist, you deal with numbers all day long, and not just part numbers. Since you are there to make a profit, it can be assumed that you are selling your goods for more than what was paid for them and this will require some mathematical skill. If your invoicing is computerized this will all be done for you, but if the system is down or an invoice must be hand written, some basic math is a must. Aside from simple addition and subtraction to obtain invoice totals, you may wish to figure discounts from a set price or percentage of profit on the sale of an item.

In the days before computerized invoicing, a price sheet supplied by the parts manufacturer may have been used to figure pricing levels for different types of customers. This would include a suggested retail price and various percentages off of retail depending on the volume of business that the customer did with you. For example, you may have had retail price, DIY (Do It Yourself) customer price, service dealer price, and stocking dealer or 'jobber' price. Calculating these discounts off of retail is very easy, just express the percentage off as .xx and multiply the retail by that figure, as in this example:

- Retail = \$10.00
- DIY = 15% off so $\$10.00 \times .15 = \1.50 off of retail
- Service dealer = 30% off so $\$10.00 \times .30 = \3.00 off
- Jobber = 42% off so $\$10.00 \times .42 = \4.20 off.

Another way to figure discounts is to multiply the list price by the percentage of retail that you want to charge. For example, if the list price is \$10.00 and you want to charge 80% of retail, multiply \$10.00 by .80 and the price becomes \$8.00.

The above formulas are useful if you want to give a customer an extra discount off of a listed price, but there will be times when you'll want to work upward from a cost figure, such as on a special ordered part. The method for doing this is not the reverse of taking a percentage off of a listed price, however. In this case the cost of the item is multiplied by a figure of more than the desired percentage of profit in order to compensate for the initial cash cost. For example, say the goal is to make a 50% profit on an item; if the item cost \$10.00 and it is sold for \$20.00, then you have made a 50% profit or margin. This is achieved by multiplying \$10.00 by 2 or 200%,

thus the cost is now half of the selling price. To prove this multiply \$20.00 by .50 and the result is \$10.00.

If you were to figure this using the reverse of the percentage off formula, you would end up with a simple percentage markup but not a true percentage of profit. For example: if \$10.00 is your cost on a part and it is multiplied by .50 for 50% you get \$5.00. Adding the two together equals \$15.00. When \$15.00 is multiplied by .50 the result is \$7.50, and since you paid \$10.00 for the part you have not made a true 50% profit on the sale. This can be a confusing concept to understand at first, but if you think of it as percentage of profit on the sale rather than a percentage of the cost price it becomes easier.

The following table lists a few formulas you may find useful when doing these calculations.

- To make a 20% profit, multiply cost by 1.25
- To make a 25% profit, multiply cost by 1.33
- To make a 30% profit, multiply cost by 1.43
- To make a 35% profit, multiply cost by 1.54
- To make a 40% profit, multiply cost by 1.67.

These formulas can be useful in determining special handling charges on seldom ordered or slow moving parts, as well as profit markup on an individual part. Some distributors may assess a minimum order fee or freight charges onto your cost, and by tak-



ing the combined price of the parts and any additional fees and figuring your markup on that, you have factored it into every piece of that order and no additional charges must be shown on the invoice. In the case of a single part being special ordered however, it is often better to list the shipping and handling charges separately, so that they can be referenced to a freight bill and verified. No matter the situation however, it is important that you realize the need to add additional freight or handling charges. When placing a special order on any item you should always confirm the shipping arrangements with the distributor and plan accordingly. If you sell a part for \$20.00 that

cost you \$10.00, but neglect to add freight or handling fees to the invoice, you will find that you make little or no profit at all.

Another area where percentages come into play is with warranty items that are pro-rated. On limited life items such as batteries, the warranty is based on a percentage scale to reflect the amount of usage before the defect or failure occurred. A battery with a 5-year warranty may offer free replacement within the first year and a percentage of the cost assessed for each month of service after that, however the pro-rate will revert to the date of original purchase, not to the one-year free replacement point. What this

means is that a battery that fails after 14 months in service will be pro-rated at 14 months and not 2 months. This is usually shown on an invoice as a sale and a return that cancel each other dollar wise, and then the pro-rate fee that the customer must pay. For example, a battery that cost \$70.00 will be charged and a warranty credit for \$70.00 issued, and then the pro-rate fee of say $\$1.50 \times 14$ months = \$21.00 is the customer cost for replacement.

MEASUREMENTS AND UNITS OF MEASURE

As a parts specialist, at some point you will have to make measurements with instruments more

Examples of Terminology

1. Outside Measuring

2. Inside Measuring

3. Stop Measuring

4. Depth Measuring

1 + 340 = 1.340"

$1 + \frac{1}{4} (\frac{16}{64}) + \frac{4}{64} = \frac{22}{64} = 1\frac{11}{32}$

Instructions for using a caliper.

Conversion Chart

Inches			Inches			Inches			Inches		
Fractions	Decimals	MM	Fractions	Decimals	MM	Fractions	Decimals	MM	Fractions	Decimals	MM
-	.0004	.0100	-	.2165	5.5000	29/64	.4530	11.5090	23/32	.7190	18.2560
-	.0040	.1000	7/32	.2190	5.5560	15/32	.4690	11.9060	-	.7283	18.5000
-	.0100	.2500	15/64	.2340	5.9530	-	.4724	12.0000	47/64	.7340	18.6530
1/64	.0156	.3970	-	.2362	6.0000	31/64	.4840	12.3030	-	.7480	19.0000
-	.0197	.5000	1/4	.2500	6.3500	-	.4920	12.5000	3/4	.7500	19.0500
-	.0295	.7500	-	.2559	6.5000	1/2	.5000	12.7000	49/64	.7656	19.4470
1/32	.0313	.7940	17/64	.2656	6.7470	-	.5118	13.0000	25/32	.7810	19.8440
-	.0394	1.0000	-	.2756	7.0000	33/64	.5156	13.0970	-	.7874	20.0000
3/64	.0469	1.1910	9/32	.2810	7.1440	17/32	.5310	13.4940	51/64	.7970	20.2410
-	.0590	1.5000	-	.2853	7.5000	35/64	.5470	13.8910	13/16	.8125	20.6380
1/16	.0620	1.5880	19/64	.2970	7.5410	-	.5512	14.0000	-	.8268	21.0000
5/64	.0781	1.9840	5/16	.3120	7.9380	9/16	.5630	14.2880	53/64	.8280	21.0340
-	.0787	2.0000	-	.3150	8.0000	-	.5710	14.5000	27/32	.8440	21.4310
3/32	.0940	2.3810	21/64	.3280	8.3340	37/64	.5790	14.6840	55/64	.8590	21.8280
-	.0984	2.5000	-	.3350	8.5000	-	.5906	15.0000	-	.8662	22.0000
7.64	.1090	2.7780	11/32	.3440	8.7310	19/32	.5940	15.0810	7/8	.8750	22.2250
-	.1181	3.0000	-	.3543	9.0000	39/64	.6090	15.4780	57/64	.8906	22.8220
1/8	.1250	3.1750	23/64	.3590	9.1280	5/8	.6250	15.8750	-	.9055	23.0000
-	.1378	3.5000	-	.3740	9.5000	-	.6299	16.0000	29/32	.9062	23.0190
9/64	.1410	3.5720	3/8	.3750	9.5250	41/64	.6406	16.2720	59/64	.9220	23.4160
5/32	.1560	3.9690	25/64	.3910	9.9220	-	.6496	16.5000	15/16	.9375	23.8130
-	.1575	4.0000	-	.3937	10.0000	21/32	.6560	16.6690	-	.9449	24.0000
11/64	.1720	4.3660	13/32	.4060	10.3190	-	.6693	17.0000	61/64	.9530	24.2090
-	.1770	4.5000	-	.4130	10.5000	43/64	.6720	17.0660	31/32	.9690	24.6060
3/16	.1875	4.7630	27/64	.4220	10.7160	11/16	.6875	17.4630	-	.9843	25.0000
-	.1969	5.0000	-	.4331	11.0000	45/64	.7030	17.8590	63/64	.9844	25.0030
13/64	.2030	5.1590	7/16	.4380	11.1130	-	.7087	18.0000	1	1.0000	25.4000

Sample of a fractional-decimal-metric conversion chart.

precise than the ruler glued to the countertop. While the micrometer has been the measuring tool of choice for the automotive machinist, it is impractical for use on the parts counter. Separate micrometers must be used for inside, outside, and depth measurements. Also, outside micrometers can also only measure within a span of one inch; for example, you would need separate micrometers to measure items between one and two inches, and two to three inches.

The best tool for use on the counter is the dial indicating, or digital read out caliper. This is a tool with one fixed and one sliding jaw. The sliding jaw is opened and the item to be measured is placed on the fixed jaw. The sliding jaw is then moved up tight against the item and a measurement is given on the indicator. Most calipers will measure in in-

crements of 1/1000 of an inch from zero to six inches or they may have two scales, one for English and one for metric. For reference, one thousandths of an inch is read as the third number to the right of the decimal point, or 0.001. Ten thousandths would be 0.010, and fifteen thousandths would be 0.015, while one and one half thousandths would be 0.0015. Digital calipers usually have a selector switch and can do both metric and English scales.

A caliper also has a set of inside jaws opposite from the fixed and sliding jaws for measuring inside diameters and a depth rod fixed to the sliding jaw for depth measurements. As with any precision tool, care must be used when handling a dial or digital caliper, and it should be put in its own storage box under the counter when not in use.

The two standards of measurement used in the United States are English and metric. English uses the traditional inch and foot, while metric is based on the meter. The metric system is based on multiples of ten and one hundred and is quite simple to use and understand, but can cause problems if you or the customer do not know that you are dealing with it. Many times a bolt or other piece of hardware, such as a brake line, may be metric even though it comes off an American built vehicle. If you are in doubt, always measure using both scales. There will also be occasions when the catalog or customer gives you a fractional measurement and it has to be converted to a decimal equivalent, such as finding a ball bearing for a non-automotive or non-standard application. There are charts available for this from tool or machinist

The screenshot shows the Vision Enterprise 7.4.48 software interface. At the top, there are navigation tabs for Home Page, Customer Maintenance, Customer Service, Retail / POS, CRM Management, Part Management, Accounts Payable, and Accounts Receivable. Below these are menu options for Customer Profile (F2), Ship Tos (F3), Current Order (F4), Part (F5), Catalog Parts (F6), Customer History (F7), Part History (F8), Order Inquiry (F9), A/R Summary, and A/R Detail. The main window displays customer information for Customer 0685882, Ship To Name TOM P, and Address 1 ATKINS RD. It also shows contact information, order type (Standard), and a list of items in the order. The bottom status bar shows 'Ord Num: New Order', 'Ord Date: 12/1/2006', 'Ord Lines: 2', 'Mdee: 51.52', 'Tax: 2.58', 'Margin Pct: 70.3', and 'Ord Total: \$54.10'.

Typical computer generated invoice for a sale. The heading lists the customer's number, name, address, and delivery instructions. The bottom portion lists the number of items on the invoice in the column marked Line. The columns to the right list Action, in this case a sale, Part Number and Description and finally Quantity and Price. Notice also the core price listed for the item on line two.

suppliers or it may be printed in the catalog you are working with.

Conversions between metric and English are not difficult, but it is usually easier to work in the scale that is given, especially when dealing with hardware or close tolerance parts. The place where you will see the most metric conversions is in engine displacement listings. For years the U.S. auto manufacturers listed displacement in cubic inches while the rest of the world used either cubic centimeters or cubic liters. Since the mid 1980s, most U.S. automakers have also gone metric, thus the venerable 350 c.i. Chevrolet engine

became the 5.7 Liter GM engine. The engine size and family group are listed on the vehicle emission tag found on the radiator support on most vehicles, so if you are in doubt ask the customer for this rather than guess.

Here are some common English-metric and metric-English conversions:

- Centimeters × 0.394 = inches
- Inches × 2.540 = centimeters
- Meters × 3.281 = feet
- Feet × 0.305 = meters
- Liters × 1.057 = U.S. liquid quarts
- U.S. liquid quarts × 0.946 = liters

- °C = (°F-32) × 0.555
- °F = (1.8 × °C) + 32.

INVOICING AND MONEY TRANSACTIONS

Whenever you sell a part, it must be invoiced or recorded so that the inventory and accounting figures remain correct. Invoicing means listing the part number and description as well as quantity and price of the goods sold. Other information listed on the invoice should be the date, an invoice number, and method of payment. With a computerized system, the date and number will be assigned automatically with the pricing de-

terminated by the customer type that is entered. A walk-in DIY customer will usually be assigned the highest level of pricing, along with a standard customer number that covers all DIYers. Professional installer customers will be assigned their own number that identifies the shop's name and address, and the appropriate pricing levels keyed to it.

After entering customer type, the quantity and number of each part must be entered. If it is an item that is sold in bulk or cut from a roll, be certain that the quantity you enter matches what the computer bills. For instance, one foot of hose may have to be entered as twelve inches.

When dealing with a customer with an open charge account, make sure all the necessary information, such as account numbers and purchase order numbers, are correct. If the part is to be delivered, be certain to get any special directions the customer may have, and relay this information to your delivery driver. If a time frame was quoted to the customer, make sure your driver is aware of this so he can plan his trip accordingly.

Some accounts are on a cash only (COD) basis due to payment problems and others are on COD because they wish to be. If a delivery is COD but there is no one there to pay for the parts, it is important that your driver knows what to do. Drivers should know to call if there is a problem and not risk losing a customer due to a misunderstanding.

After entering all of the items to be billed you may be automatically prompted for information such as special shipping instructions or freight charges if any, or you may have to remember to enter them if not prompted. Some systems may show discounts to DIY customers on a line by line basis or they

may total the amount and give a percentage off that, but installer customers may want to know a list price as well as cost on each part so they can charge their customer accordingly.

After all of the necessary information is entered and you are ready to complete the sale, you must identify the form of payment. With an installer customer who has an open charge account, this means that no money will be collected for that invoice at the time of the sale. All other sales must be released as some form of cash or charge card payment and reconciled to the day's cash total at the end of the business day.

A credit or return goods invoice will contain all of the information previously mentioned along with some additional information. In all cases, it should be noted whether the part being returned is new and being put back into inventory, a warranty defective return, or a core. A part noted returned as new, when it is really a defective return, will be added back into the store's inventory, when in fact, it is not really there. You may also have to provide an original sales invoice number before a credit can be issued. This not only proves that the item was legitimately purchased, but also gives you a chance to make sure that the amount being refunded is the same as what was originally charged. Some systems may also prompt you for the reason the part is being returned, such as wrong part, customer cancelled the job, etc.

All of the information contained on a computer generated invoicing system must also be on any handwritten invoices you produce. Since the benefits of computerization are obvious, such as instant inventory upgrading and consistent pricing, you may never have to handwrite an invoice, but a

few special rules apply if you do. Handwriting must be neat and legible and particular attention paid to pricing. If the person updating your inventory cannot read a part number, the shelf count will be wrong, and pricing errors can lead to misunderstandings with the customer in the future.

The final step in a cash sale transaction is collecting the cash or processing the charge card sale. A computerized system will usually ask for form of payment, either cash, check, or charge card. If the customer pays cash, be sure to note the amount they give you out loud and do not put the cash in the register until you have counted out any change back to them. A customer that hands you \$10.00 for a \$5.00 sale, but believes he handed you \$20.00, can get very upset and impossible to deal with. By keeping the money where it can be seen until the transaction is completed, this problem can be avoided. Care should also be taken when counting out the customer's change so that you neither return too little or too much. In most cases the computer or the cash register will ask for the amount tendered by the customer and deduct the sale from it, telling you how much change to give back. This eliminates mental arithmetic, but you still must be careful of new bills that can stick together and giving back bills of the wrong denomination; by counting the customer's change back to them, this can be avoided completely.

If your store accepts checks, you will have to look for a few basic things even if you use a check guarantee service. These should include a bank printed name and street address, and a telephone number and/or a driver's license number furnished by the customer. A check clearing service may ask for the account number

Vision Enterprise 7.4.48

Home Page Customer Maintenance Customer Service Retail / POS CRM Management Part Management Accounts Payable Accounts Receivable

Customer Profile (F2) | Ship To: (F3) | Current Order (F4) | Part (F5) | Catalog Parts (F6) | Customer History (F7) | Part History (F8) | Order Inquiry (F9) | A/R Summary | A/R Detail

Customer: TOM > Ship To: 001 - TOM > Company: 01 - Automotive > Warehouse: 009 - Salem

Customer: 0985882 * Contact: [Dropdown]
 Ship To Name: TOM P Phone / Ext: 101-101-1010
 Address 1: ATKINS Special Instr: [Text]
 Address 2: [Text] Billing Code: [Text]
 Address 3: [Text] Order Source: [Dropdown]
 City State Zip: SALEM NH 03079-18 Customer PD: [Text]
 Map Location: 1 - Addison Run Operator Hold: [Text] Print: [Text]
 Delivery Method: Normal Delivery CSR: 1 - CUSTOMER SERVICE

Order Number: [Text]
 Order Type: Standard [X]
 One Step []
 C/M Pickup []
 C/M One Step []
 Rebill []
 Quote []

New Order [Button]
 Accept Order [Button]
 Payments [Button]
 Order Details [Button]

Action: Credit [], Inventory Return [X], Warranty [], Core []

Product More... Discount Calculator

Line	Part Number	Ord	UOM	Unit Price	Unit Cost	Disc %	Override Price
		Ship	B/D	Core Price	Core Cost	List Price	Price Source
		Inv	Cncl	Est Price	Est Cost	Margin %	
Vendor	Direct Ship						
		Return Tag					

Price Hold []
 Local Stock Available [Text]

Line	Action	Part Number	Description	Order Qty	UOM	Unit Price	Core Price	Est Price	Ship Qty	B/D Qty	Inv Qty	Cncl
001	Inventory Return	WX51515	FILTER	-1	EA	9.850	0.000	-9.85	0	0	0	

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Customer Profile (F2) | Ship To: (F3) | Current Order (F4) | Part (F5) | Catalog Parts (F6) | Customer History (F7) | Part History (F8) | Order Inquiry (F9) | A/R Summary | A/R Detail

Customer: TOM > Ship To: 001 - TOM > Company: 01 - Automotive Supply > Warehouse: 009 - Salem

Customer: 0985882 * Contact: [Dropdown]
 Ship To Name: TOM P Phone / Ext: 101-101-1010
 Address 1: ATKINS Special Instr: [Text]
 Address 2: [Text] Billing Code: [Text]
 Address 3: [Text] Order Source: [Dropdown]
 City State Zip: SALEM NH 03079-18 Customer PD: [Text]
 Map Location: 1 - Addison Run Operator Hold: [Text] Print: [Text]
 Delivery Method: Normal Delivery CSR: 1 - CUSTOMER SERVICE

Order Number: [Text]
 Order Type: Standard [X]
 One Step []
 C/M Pickup []
 C/M One Step []
 Rebill []
 Quote []

New Order [Button]
 Accept Order [Button]
 Payments [Button]
 Order Details [Button]

Action: Credit [], Inventory Return [], Warranty [X], Core []

Product More... Discount Calculator

Line	Part Number	Ord	UOM	Unit Price	Unit Cost	Disc %	Override Price
		Ship	B/D	Core Price	Core Cost	List Price	Price Source
		Inv	Cncl	Est Price	Est Cost	Margin %	
Vendor	Direct Ship						
		Return Tag					

Price Hold []
 Local Stock Available [Text]

Line	Action	Part Number	Description	Order Qty	UOM	Unit Price	Core Price	Est Price	Ship Qty	B/D Qty	Inv Qty	Cncl
001	Warranty	TSR58-323	DOMESTIC WATER PUMP-RMFD	-1	EA	37.670	4.000	-41.67	0	0	0	

These invoices contain all of the same information in the heading as the previous sale invoice, but the listings in the Action columns are different. On one invoice the Action column is marked Inventory Return, which will place the part back into the stores inventory. On the other it is marked Warranty, which will refund the customer's money but not place the part back into inventory.

as well as the other information and they may also be wary of low numbered checks. If the check fails to clear the bank and it has been processed by one of these ser-

vices, they will cover it and pursue the person who passed the check. Since this service is usually offered on a monthly fee basis, whether you use it or not, any check re-

ceived should be processed unless the person is a regular or well-known customer.

Check services will not honor second party checks, which are

checks that have been made out to the customer that they then try to pass along to you. Unless you know both parties and are willing to cover the cost if the check bounces, it is wise to avoid these checks altogether.

Credit and debit cards are being used more and more and it's predicted that cash will be phased out completely in the future. A credit card is issued by a bank or other financial institution and it extends a line of credit to that customer that can be used anywhere the card is accepted. A debit card can work in the same way, but the customer also has the option of using it to draw against an existing bank account, just like writing a check. Your store is charged a fee, a percentage of the sale total, by the issuer of the credit or debit card every time you take one as payment. However, laws prohibit adding on fees to cover these charges. Credit card readers are used to read the account number and expiration date from the magnetic strip on the back of the card. In the event of a sale made over the phone or a card with a bad magnetic strip, the account number and expiration date will have to be manually entered. Customers using debit cards will also have to enter a PIN, or Personal Identification Number, on the keypad and the magnetic strip must be readable; account numbers and expiration dates cannot be manually keyed in.

Credit card terminals are tied directly into a clearing center, so once the account number and sale amount are entered, approval or denial will be known immediately. If the sale is denied, try to be as discrete and understanding as possible when you inform the customer. There are other reasons besides non-payment for a credit card company to decline a sale and

these may be beyond the customer's control. It can be very embarrassing for the customer to be told his credit is no good, especially in a store full of people. Finally, be certain that the signature on the back of the card matches the signature on the invoice, or ask for identification if you are unsure.

WORKING WITH OTHER EMPLOYEES AND COMPANY POLICY

Besides dealing with the customers you will also have to work with and understand your fellow employees. A day spent in conflict is unhealthy as well as unproductive, so any conflicts should be brought out in the open and resolved before they escalate. Problems over scheduling or assigned jobs should be taken up with management and their decision taken as final. An effective manager knows how best to use his employee assets, so any thoughts or recommendations should be directed to him or her rather than taking the form of a complaint voiced to another employee. Trying to undermine someone else's authority will only stir up hard feelings all the way around.

Communication and the exchange of information are vital to your job and your business. A well-run store thrives on written, oral, and electronic communication between customers and store personnel and between fellow employees. This applies to any orders or projects you may have in the works. If you are going to be away from the store, make someone aware of what you have done in case problems or the need to follow up arise.

Communication and cooperation between employees also extends to training newly hired workers. As an experienced counterperson you may consider this an

extra drain on your time, but in the long run it will pay off. The more a fellow parts specialist knows the less they will have to ask you. You may have certain commercial customers that only want to speak with you when they call for parts, and while this reflects well on you, you can't be everywhere at once. By helping fellow employees gain the knowledge they need, you will also help to lighten the load on yourself. If you have customers that complain about the service being provided by a new counterperson, try to explain that it takes time to train someone, even if they already have a great deal of automotive knowledge. Let the customer know that you are keeping an eye on the new person and ask him to have the new employee ask you if he seems in doubt about anything. Don't ever think that by training a new employee too well you will be out of a job. If you know and do your job well and pass this knowledge on, the only place you will be moving is up. Remember, you didn't know everything when you first started out behind the counter.

In addition to working with other employees, you must also learn to work within the rules and procedures set by management. These are all in place for reasons that may not be obvious to you, but were deemed important enough for management to make them. Some may be common sense safety rules or insurance regulations, but others may have to do with customer confidentiality or payment policies, and all should be taken seriously. If you have a problem or suggestion concerning any company rule, it should be brought up with management in a direct manner, not through employee gossip, or worse yet by a customer's comment to

management. Negative thoughts and comments about the company told to a customer can give them bad feelings about dealing with you and cause them to go elsewhere. If you have a problem, be brave enough to address it with those that can do something about it. Remember that the customer is your reason for being there, but you work for the management and they are the ones who pay you.

SAFETY, SECURITY AND HOUSEKEEPING

Auto parts stores are full of chemicals and solvents that are harmful to people and the environment if improperly used or disposed of. Part of your responsibility as a parts specialist is to insure that every aspect of their usage is done in a legal manner. You or your employer could face serious legal problems for failure to follow OSHA (Occupational Safety and Health Administration) and EPA (Environmental Protection Agency) regulations. One material you might deal with on a regular basis is refrigeration gas, either R12 or R134a. R12 is no longer available commercially while R134a is now sold in 1-pound cans for use by consumers. At one time customers who purchased R12 must have completed a certification program in refrigerant use and been issued a card indicating they had. Common practice was to print the certificate number on any invoice for the R12 type of refrigerant that was sold. This is no longer an issue but it gives you an idea of the nature of how these rules and regulations can affect everyone in the supply chain. With the increasing emphasis being placed on carbon emissions and the tracking of hazardous solvents from manufacturer to end user — cradle to grave — these types

of regulations will only become more common as time goes on.

Manufacturers and distributors of chemicals and solvents are required to provide a Material Safety Data sheet, or MSD sheet for short. This is a document that lists the chemical properties, reactivity with other chemicals data, potential health hazards and precautions, combustion hazard, and storage and disposal instructions. These sheets must be made available to anyone who uses or has contact with any regulated material in your facility, including customers and technicians. Most facilities keep them in a binder or file drawer and make photocopies for anyone who asks. While this may seem like a lot of trouble, it can save you and your employer from lawsuits filed by private individuals or state and federal officials. An alternative method of obtaining MSD sheets is via the Internet. Most manufacturers have made this information available online rather than having to print and distribute large amounts of documents. Whichever method is in use at your facility it is your job to know how to obtain and pass along that information. The list of what is considered hazardous material in your store can be surprisingly long and can include everything from paint thinner to simple floor cleaners. You may also be required to comply with laws regarding transportation of hazardous materials in any delivery vehicles you operate. This is usually only a matter of filling out a form for the driver to carry with him, and unless you are dealing with large quantities, no special license or placarding is required. However, if you are in doubt, check with your manager.

Used oil and lubricants are also considered hazardous materials

and must not be dumped or discarded indiscriminately. Many of these can be recycled if kept in separate containers and not contaminated. The presence of chlorinated solvents in used motor oil for example, can make it unsuitable for recycling. Another option for some used oils is to burn them in an approved waste oil furnace, but there can be no coolants mixed in, so care should be taken to keep things separated. Also, in some localities if you sell oil you may be obligated to recycle customers' used oil, so be sure to check with your supervisor if in doubt.

Light housekeeping is a part of the auto parts specialist's job. At the very least, you should take responsibility for your own workstation, but you should strive to keep the rest of the store clean, too. That may require sweeping, dusting, and facing the merchandise. These chores may be assigned to a junior parts specialist, but store cleanliness should be important to every employee.

Counter tops and workstations should be kept neat and orderly. Any parts that are pulled to show a customer or catalogs removed from the rack, should be returned as soon as possible and any notes you take put in one spot. This not only presents a better appearance, it can save you or someone else the trouble of having to hunt down what you have left out. Small untagged parts and fittings in particular should be put away immediately, while their location and number is still fresh in your mind. Your company may or may not have a policy about food and drink at the counter, but it can put some customers off to see you eating in front of them. At the very least, liquids should be kept away from computer keyboards and important paperwork.

A clean display area and counter area present a professional appearance to incoming customers, but the areas they don't see are just as important. Storerooms and aisles should be routinely swept and straightened up to prevent lost inventory and accidents. Trashcans and ashtrays should be emptied before they overflow and restrooms kept clean. Lunchroom refrigerators and break areas also should be cleaned to prevent rodent and insect problems.

Safety should also be a concern of the parts specialist. Any dangerous conditions should be reported to your supervisor, and action taken to fix them. This could be anything from wet floors in the customer display area to defective lifting equipment used in the shipping and receiving area. You should always use proper lifting techniques, and never climb on the shelving units. If an item is too high up on a shelf, get a ladder. Injuries cost everyone involved with the business, not just the injured party and the owner, so make sure you and your coworkers know and observe all the proper procedures.

Fire safety should always be a concern. There are many flammable materials stored and used in a typical parts store and care must be used when dealing with them. Under no circumstances should smoking be permitted anywhere near charging batteries or paint mixing stations. Be aware of fire extinguisher locations, and check periodically to make sure they remain fully charged. In the event of a fire, there should be a predetermined meeting place outside the building, and a head count taken to make sure everyone is out.

Security around your store will mainly concern theft and property protection. In management's

case, it may also cover daily cash receipts and cash drawer totals at the end of a business day. Ideally, your showroom should be set up so that all of the display racks and gondolas are visible to anyone working behind the counter, but this is not always possible. To help minimize the risk of theft, smaller items such as wrenches or sockets can be displayed behind the counter or in an enclosed display case. Another method that manufacturers have devised to deter theft of smaller items is by carding them or putting them in blister packs. The larger, often bulky packaging makes it harder to conceal in clothing or pockets. Getting out from behind the counter when customers are browsing in your display area is not only good salesmanship, it also lets you keep an eye on what you have. By taking a look around at least once every day, you can see if an item is missing for longer that it would normally take to reorder it, and determine if it was legitimately sold or not.

Employee theft can be an even greater threat than that from outsiders. Every part that leaves your store should be invoiced or accounted for in some way. People can think of a thousand different ways to try to beat the system, but if this one simple rule is followed none of them will work. Since the only people leaving the store with merchandise should be customers and delivery drivers, this is not too hard to accomplish. Any side doors or delivery entrances that do not have to be kept open should be closed and locked, and any unauthorized people loitering around should be pointed out to management. If your company does not have a specific policy on employee purchases, you may want to have either a manager or other employee ring up anything

that you buy just to remove all doubt. A walk around the building at closing time to make sure all doors are locked and delivery vehicles secured should also be a part of the daily routine. Theft is not a victimless crime; it affects the stores profitability, which will directly affect your paycheck, so it is in your best interest to do all you can to prevent it.

TOOLS AND TERMINOLOGY OF THE TRADE

Even if you have been around the parts business for awhile, you are bound to run into a part name or description that makes you scratch your head, so imagine what a newcomer or DIY customer might think. With catalog space at a premium, abbreviations and acronyms are used extensively. The catalog should have a table listing these and their true meanings and you would do well to use it rather than guess. Different aftermarket manufacturers may use the same abbreviation to mean different things, so you must be careful. As the use of computerized systems in vehicles has grown, so too has the use of acronyms, or initialized descriptions of them, grown. For instance, an upper control arm was never referred to as a UCA, but for some reason an Engine Control Module is an ECM. OEM (Original Equipment Manufacturer) manufacturers, as well as aftermarket suppliers, may use different terminology for the same component, so be certain the function of what you are looking up is what the customer really wants.

Just as the automobile has changed over the years, so have the tools used to repair it. There are many specialized tools that might only have a use on one particular year and model of vehicle, and no individual would want to have

ABBREVIATIONS

A/C.....	Air Conditioning ¹	Inst.....	Installed/Installation
Acc.....	Accessory	L.....	Liter
AIR.....	Air Injection Reactor	LHD.....	Left Hand Drive
Alt.....	Alternator	LPG.....	Liquid Propane Gas
Alum.....	Aluminum	mm.....	Millimeter
AOT.....	Automatic Overdrive Transmission	MT.....	Manual Transmission
Assy.....	Assembly	Mtd.....	Mounted
AT.....	Automatic Transmission	NA.....	Not Applicable
Aux.....	Auxiliary	NR.....	Not Required
AWD.....	All Wheel Drive	NS.....	Not Serviced
bbl.....	Barrel	OD.....	Outside Diameter
BBC.....	Bumper to Back of Cab	OE.....	Original Equipment
Brkt.....	Bracket	OHC.....	Overhead Cam
Calif.....	California	PC.....	Police Car
Can.....	Canada	PS.....	Power Steering
Carb.....	Carburetor	PU.....	Pick-Up
cc.....	Cubic Centimeter	Rad.....	Radiator
CC.....	Commercial Chassis	Res.....	Reservoir
CJ.....	Cobra Jet	Rev.....	Reversible
CW.....	Clockwise	RHD.....	Right Hand Drive
CCW.....	Counterclockwise	RWD.....	Rear Wheel Drive
CID.....	Cubic Inch Displacement	SC.....	Standard Cooling
COE.....	Cab Over Engine	SCJ.....	Super Cobra Jet
Cont'd.....	Continued	Serv.....	Service
Conv.....	Conventional	SEO.....	Special Equipment Options
Cyl.....	Cylinder	Spd.....	Speed
Dia.....	Diameter	Sta. Wag.....	Station Wagon
Dies.....	Diesel	Std.....	Standard
ECS.....	Emission Control System	Susp.....	Suspension
EFI.....	Electronic Fuel Injection	Sys.....	System
EGR.....	Exhaust Gas Recirculation	SVO.....	Special Vehicle Operations
Eng.....	Engine	TBI.....	Throttle Body Injection
Excl.....	Except	TC.....	Turbo Charged
FI.....	Fuel Injection	TE.....	Thermactor Emission
F.V.S.....	Forced Ventilation System	Temp.....	Temperature
FWD.....	Front Wheel Drive	TPI.....	Tuned Port Injection
GVW.....	Gross Vehicle Weight	Trans.....	Transmission
HD.....	Heavy Duty ²	US.....	United States
HDC.....	Heavy Duty Cooling	Var.....	Variable
Hi-Perf.....	High Performance	WB.....	Wheel Base
HO.....	High Output	w/.....	With
ID.....	Inside Diameter	w/o.....	Without
IMCO.....	Improved Combustion	2 WD.....	2-Wheel Drive
Incl.....	Including	4 WD.....	4-Wheel Drive

¹ AC = This term will always mean Factory Air Conditioning – not dealer installed or field installed.
² HD = Heavy Duty and Standard Duty products are not interchangeable. Heavy Duty and Standard Duty refers to a specific O.E. application and should never be considered as optional applications.
 NOTE: An alpha or numeric character after the engine listing or "VIN Code =" designates the code given to the engine by the O.E. manufacturer. This code is usually found in the 4th-8th position of the V.I.N. Some specific applications require this code to determine component production changes for dual listed engine sizes.

Abbreviations listing page from a parts catalog, showing use of acronyms as well as abbreviations. (Courtesy: Four Seasons Temperature Controls)

them all. Usually a shop or dealership will purchase specialized tools for everyone in the shop to use, but the technician is still responsible for at least the basic hand tools. As a parts specialist you may never have occasion to own or even use these tools, but you should have a basic knowledge of them so you can effectively explain their usage and sell them.

The most common ones for removing fasteners, such as wrenches, hex keys, pliers and screwdrivers, are easy enough. Wrenches are used for removing hex headed fasteners. They can be either open ended where only two sides of the fastener are gripped or box ended where the wrench contacts all six points of the fastener. Variations can include

curved and offset ends for hard to access fasteners and ratchet end wrenches that allow the fastener to be turned without removing the wrench at the end of every stroke. Screwdrivers and hex keys work by engaging either a slot or a six-sided hex in the head of the fastener. In addition to the basics you should try to learn as much as possible about some of the specialty tools. The tool catalogs themselves can teach you a great deal about what may be needed to change a simple part that you sell every day, yet were unaware that anything special was needed. This could be a thin walled socket for changing a Ford ignition module, or a special fan clutch wrench for replacing a water pump. Other things such as a ball joint press or MacPherson strut spring compressor may not be in the toolbox of the average DIY customer, and they should be told of the necessity for having them when buying these parts. Brake service is another area that may require special tools for retracting caliper pistons or bleeding hydraulic lines.

With the advent of computerization, vehicles now have the ability to diagnose themselves and store Diagnostic Trouble Codes (DTCs) in the ECM. Vehicles produced since 1996 all have an OBD II diagnostic link to access these codes; the access port and the codes are universal between OEM manufacturers. Before that time codes were accessed either through a scan port particular to the OEM or by jumping across a pair of terminals in the port and reading the flashes of the MIL (Malfunction Indicator Light), or Check Engine light. With the proper scan tools, these codes can be retrieved and direct the technician to the problem much faster than using the trial and error parts replacement method.

A point to remember, however, is that just because a scan tool has retrieved a stored fault code doesn't necessarily mean that the part indicated in the code description is defective. For instance, a code pointing to a bad MAP (Manifold Absolute Pressure) sensor could be something as simple

as a disconnected vacuum line. While scanners and diagnostic tools are available in models ranging from as low as \$40.00 up to several thousand dollars, they are still only as good as the technician using them.

Since vehicles are continually evolving, the tools to service them

will also, and every day can present a new learning experience for you. This also presents opportunities for added sales and greater customer satisfaction if you take the time to learn what tools are needed and how to use them.

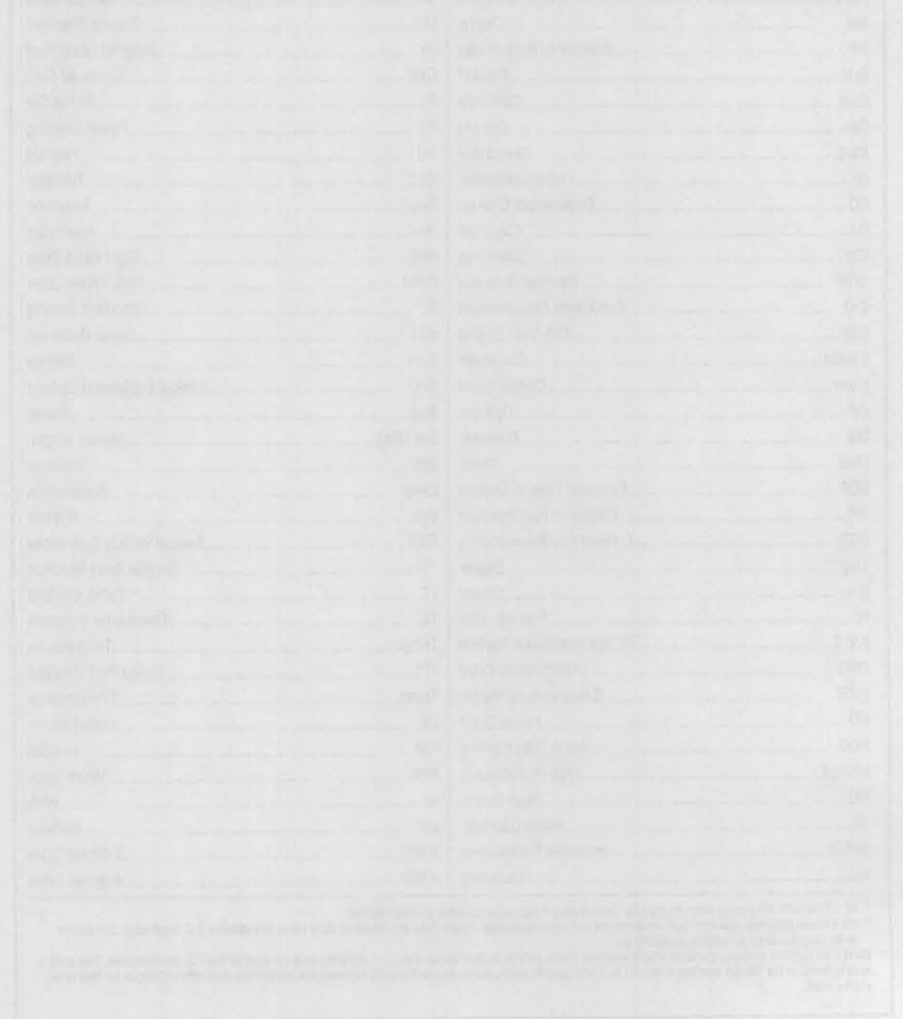


Figure 1. A scan tool can be used to retrieve and clear diagnostic trouble codes (DTCs) from a vehicle's computer memory.

The scan tool can be used to retrieve and clear diagnostic trouble codes (DTCs) from a vehicle's computer memory. The scan tool can also be used to perform various diagnostic tests, such as monitoring engine RPM, throttle position, and oxygen sensor voltage. The scan tool can also be used to perform various diagnostic tests, such as monitoring engine RPM, throttle position, and oxygen sensor voltage.

It is important to note that the scan tool is only as good as the technician using it. The technician must have a good understanding of the vehicle's systems and be able to interpret the data correctly. The scan tool is a valuable tool, but it is not a magic wand.

Customer Relations and Sales Skills

CUSTOMER TYPE, NEEDS AND SKILL LEVEL

The first question you should ask is: what type of customer are you dealing with? ...

Next, you need to identify the customer's needs. ...

Finally, you need to assess the customer's skill level. ...

IDENTIFYING THE CUSTOMER

When you are dealing with a customer, it is important to identify their needs and skill level.

Your approach to a customer should be based on their needs and skill level. ...

Identifying the customer's needs and skill level is a key part of the sales process. ...

When you are dealing with a customer, it is important to identify their needs and skill level.

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IDENTIFYING THE CUSTOMER

When you are dealing with a customer, it is important to identify their needs and skill level.

Customer Relations and Sales Skills

CUSTOMER TYPES, NEEDS AND SKILL LEVELS

As a parts specialist, you will encounter customers with all kinds of backgrounds and skill levels, ranging from the master technician to someone that's barely able to drive. The common thread between them is that they have come to you for help with an automotive problem. In order for you to do this, you must first determine one from the other.

Most parts stores try to cater to both the professional installer and the DIY market in one way or another. The professional installer market can be easier in some respects because the customer will usually know what they need and be more concerned with availability and pricing. This doesn't mean that you shouldn't try to upgrade or make related sales, or that less sales skill is required; it means that sometimes your delivery truck is worth more to them than your sales delivery.

DIY customers offer different challenges in that they don't always have a clear idea of what they need or why they even need it. Not all of them are like this, some are every bit as qualified as any master technician, but you have to determine skill levels in order to make a profitable and effective sale. Selling unnecessary or incorrect parts, or parts that are beyond the customer's ability to install, will only create returns and hard feelings later on. By asking questions about why they are replacing a part, you can determine the nature of their problem and make suggestions or offer

options. While it may seem like more work, it really is not all that hard, and the benefits are worth the effort.

GREETING THE CUSTOMER

Your appearance is an unspoken form of communication. Just as your employers recognize the need for neat and well-organized premises, you should recognize the need for good personal and professional appearance. If you present a professional image, you will not only help your employer, but you will build your professional stature with the customer. After all, would you eat in a restaurant if everything, including the help, looked filthy? You only get one chance at a good first impression, and by making the most of it, you will improve your chances of a successful sale.

Proper salesmanship starts when the customer first contacts you, either on the phone or walking through the door. Make sure you greet any walk-in customers promptly and cheerfully, and don't be afraid to get out from behind the counter and help if you see them looking over items that are on display. When you answer the phone, give your name and the store name and ask how you can help them. Answer the phone with a positive attitude, even if you are occupied with other tasks. Your attitude is conveyed in your tone of voice and it's very easy for the person on the other end to pick up your mood just by how you introduce yourself on the phone. Sometimes it's better to let it ring

one more time while you compose yourself rather than just picking up and mechanically reciting your greeting.

If you are waiting on a counter customer and the phone rings, determine their needs and ask the phone customer if they will hold while you finish with the task at hand, or take their number and ask if you can call back. If you place a phone customer on hold don't leave them hanging even if you haven't finished with the task at hand; a few minutes of listening to a dead phone line can seem like an eternity to the person on the other end. If you think you are going to be a while, ask the customer on hold if they would like to continue to hold, or see if another counter person can help. All customers are equally important and you should always try to take the customers, both phone and walk-ins, in the order they came in. If you must drop one customer to wait on another, ask someone else to continue with the first one for you. While no customer is any more important than another, there can be situations that demand immediate attention, so be sure not to leave anyone hanging or you will have two angry customers.

MEETING CUSTOMER NEEDS AND MAKING THE SALE

After you have greeted the customer, you must determine their reason for coming into your store, which means that you have to put your vehicle systems knowledge into practice. You will be dealing with customers of widely different

mechanical abilities and communication skills, so the better yours are the more effective you can be. It is not your job to diagnose every customer's vehicle, but if their vehicle complaint does not match the part they are asking for you may want to get a little more involved. Knowingly selling them something that will not fix the problem will almost guarantee that the part will be returned as defective or in a used condition. The first thing you must do is gather any vehicle information needed to help them. This may include serial number or VIN (Vehicle Identification Number), production date, casting numbers off the old part, or option codes, as well as basic make and model. Guesses or mistakes at this point will almost guarantee a wrong part, so listen carefully to what the customer says.

Once you have the necessary information, you can explain the various options available, such as a new or rebuilt unit if applicable, or different grades of brake pads, etc. If the customer is price shopping or buying strictly on the basis of price, make sure you are comparing like for like. While the store down the street may be cheaper, the part might not serve the purpose or it may not carry the same warranty as what you are selling. When selling an item with a generous warranty it should be promoted as an added product benefit, it is not really a feature of the product itself. Selling on the basis of warranty alone does not let the customer know what's to be gained from using your product and may give the customer the idea that the product will fail sooner than another brand. A product feature is something that's built into the part; a product benefit is what's to be gained by using it. If the customer is shopping strictly on the basis of product warranty, be sure

to explain what is and isn't covered and what documentation will be needed if its use becomes necessary. You should also take the time to explain return policies on new parts, especially if the customer is unsure of what their problem might really be.

When filling an order, you should always look for ways to upgrade the sale, such as through related parts sales, promoting any shop services you may offer, or promoting a better grade of the same product. Upgraded and related sales benefit both you and the customer by insuring that they have all of the parts needed to complete their repair as well as adding to your profits. For example, if a customer asks for a battery, you could ask about the condition of the cables and hold-down brackets. Customers buying brakes could be reminded about your drum and rotor turning service, or asked about the condition of the calipers and related hardware. Most brake linings are offered in several grades, and by determining the customer's driving habits you may be able to suggest an upgraded product that better suits their needs. Sometimes people get in a rush to get things done and do not always look at the whole job. A little reminder from you can save them another trip into the store and also help the store's bottom line. Some professional installers may automatically expect you to supply any necessary related items, but this is something you will only learn through dealing with them over time. Some customers will undoubtedly balk at having to spend a penny more than the absolute minimum when it comes to their vehicle but by combining good vehicle and product knowledge with good salesmanship, you should both benefit from the transaction. If you are honest with them

and don't try to oversell, and can give valid solutions to their vehicle problems, you will face very few sales objections.

Good salesmanship also means that you should never talk badly about a competitor's products or reputation. Rather you should take a more professional approach and tell the customer why your product is better suited to their needs. If you don't believe a product the customer is asking for is correct for their needs, try to explain why but do not argue or ridicule them. In the long run, it is the customer's choice to make and their money to spend. However, if you honestly believe that a product may cause safety problems, or expose the store to liability, consult with your manager or supervisor before making the sale.

The final step is to close the sale, or get the customer to commit to the purchase. When closing a sale, you may have to ask for it. Some people have to be asked to commit to any purchase, especially if it is not a necessity or if they consider it to be expensive. After you have explained your products and the benefits of each, ask which one they would like, but never be pushy or insistent. After the sale, remember to thank them, even if no purchase was made. A well-treated customer will return again and again.

COMPLAINTS AND RETURNS

At some point you will have to deal with returned parts, either defective, incorrect, or ordered in error. If the part is wrong because you looked it up wrong, admit your mistake and apologize. Even if the customer gave you incorrect information, do not try to place blame. Just do what is needed to obtain the correct part and move on. Some customers may order parts without really knowing if

they will fix their problem or what is involved in installing them, and then wish to return them. As long as the merchandise is new, uninstalled and the packaging is in saleable shape, this may not be a problem, but be wary of electronic and tune-up components. A person without the proper diagnostic tools may try to fix their vehicle by replacing parts until it runs, and then want to return the stuff that didn't fix it. When you take back returned goods you will have to determine the reason for the return and handle it in the appropriate manner. Warranty or defective returns should be accompanied by the necessary paperwork and sales

receipts and tagged so they are not mistaken for cores or new parts. New products returned simply because they were not needed or did not perform the way the customer expected should be examined for re-saleability or set aside for return to the vendor depending on the case. In all instances, a return should be accompanied by a sales receipt both to prove that the item came from your store and to verify that any refund given is for the correct amount.

Any complaints about products and service should be taken seriously and acted upon right away. Don't let a customer think you don't care, or take them for

granted. If you do they will not be a customer for very long. This is particularly important with professional installer customers; for them time is money, and the wrong parts or comeback repairs can cost them dearly. Never engage in a shouting match or lose your temper with a customer even if they do. By acting in a calm and rational manner, you can defuse the situation and get to the root of the problem much more quickly and easily. Once you have determined the cause of the problem, do whatever you can to fix things but never promise what you can't deliver or the situation will repeat itself.

COMPLAINTS AND RETURNS

At some point you will have to deal with returned goods. While defective inventory is ordered in error if the part is truly defective you should be up front about that. Your mistakes are obvious. Even if the customer gives you incorrect information, do not try to blame blame. Just do what is needed to obtain the correct part and have your customer's order. Some customers may order parts without really knowing it

supply you necessary return items. For this is something you will only learn from the dealing with them over time. Some customers will undoubtedly balk at having to spend a penny more than the price minimum when it comes to that vehicle but by comparing good vehicle and product knowledge with good information, you should feel better from the time you see the customer with their

problem. Getting on the ball at return time does not let the customer know who's who and may mean using your product and may give the customer the idea that the product will last longer than another brand. A product failure is something that's built into the part a product failure is what to be aware of using it. If the customer is shopping online, on the part of product manager because

Vehicle Systems

The engine is the heart of the vehicle, converting fuel into mechanical energy. It consists of several components, including the cylinder block, crankshaft, pistons, and valves. The engine is driven by the alternator, which generates electricity for the vehicle's electrical system. The alternator is connected to the battery, which provides power to the engine and other components. The battery is also used to start the engine. The engine is connected to the transmission, which transfers power to the drive shaft and the wheels. The transmission is a gearbox that allows the driver to change gears. The drive shaft is a long shaft that connects the transmission to the rear axle. The rear axle is connected to the rear wheels. The front axle is connected to the front wheels. The suspension system is designed to absorb bumps and provide a smooth ride. It consists of the frame, springs, dampers, and steering knuckles. The steering system allows the driver to control the direction of the vehicle. It consists of the steering wheel, steering column, and steering rack. The brakes are used to slow down or stop the vehicle. They consist of the brake pedal, master cylinder, brake lines, and brake pads. The exhaust system is designed to remove exhaust gases from the engine. It consists of the exhaust manifold, catalytic converter, and tailpipe. The cooling system is designed to keep the engine from overheating. It consists of the water pump, radiator, and fans. The fuel system is designed to deliver fuel to the engine. It consists of the fuel tank, fuel filter, fuel pump, and fuel injectors. The electrical system is designed to power the vehicle's electrical components. It consists of the battery, alternator, and various electrical components. The chassis is the structural frame of the vehicle. It supports the engine, transmission, drive shaft, rear axle, front axle, suspension, steering, and braking systems. The chassis is made of steel or aluminum. The body is the exterior of the vehicle. It is made of sheet metal and is attached to the chassis. The body is designed to protect the occupants and provide a comfortable and safe environment. The interior of the vehicle is designed for comfort and safety. It includes the seats, dashboard, steering wheel, and various controls. The interior is also equipped with safety features such as seat belts and airbags. The vehicle is designed to be durable and reliable. It is built to withstand a variety of driving conditions and to provide a long service life. Regular maintenance is essential to keep the vehicle in good condition. This includes checking the oil, tires, brakes, and other components. Following the manufacturer's recommendations for maintenance is the best way to ensure the vehicle's longevity and safety.

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ENGINE MECHANICAL PARTS

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Vehicle Systems

It would be difficult to provide automotive parts and information without a general knowledge of the automobile and its operation. The better you know automotive systems, the more helpful you will be to customers, and therefore, more valuable to your employer.

ENGINE MECHANICAL PARTS

Today's cars use one of four basic propulsion types: gasoline (piston), diesel (also piston), rotary, and a combination of conventional fuel and electric known as a hybrid. By far the most common type of automotive powerplant used in the United States is the gasoline four-stroke piston engine. Diesel engines were once found almost exclusively in heavy-duty trucks and equipment but are now also very popular in light- and medium-duty pickups, and some manufacturers offer a diesel option in some of their cars. Mazda has manufactured rotary engine-equipped automobiles and sold them in the U.S. since the early 1970s.

Hybrid vehicles can operate on either conventional fuel with a small four-stroke piston engine or with an onboard electric motor and battery system. In most cases the gasoline engine is the primary power source and the electric motor is used as an assist when passing or climbing a hill. This allows a smaller, more fuel efficient engine to be used. When the vehicle comes to a stop the engine may shut down completely, and when the throttle pedal is depressed the electric motor will provide the initial power with the gas engine starting as the vehicle begins to

move. Battery charging is provided by the gas engine and through regenerative energy taken from the brakes whenever they are applied.

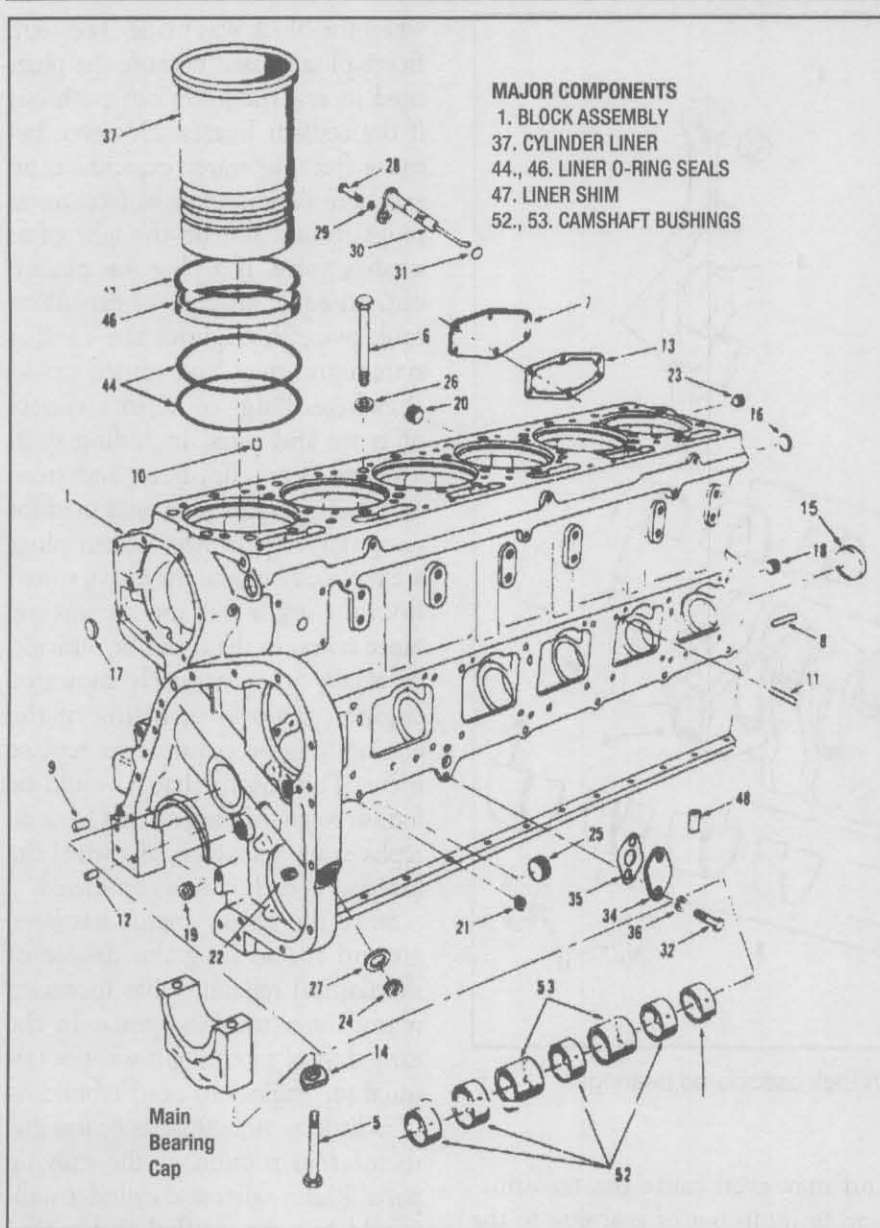
The three major types of engines are similar in that they are internal combustion engines. A mixture of air and fuel vapor is taken into the engine, compressed and then ignited; the resulting expansion (due to heat) of the gases is then converted to motion. In gas and diesel piston engines, the expanding gases are trapped within a cylinder where they push on a movable floor, or piston, that travels along the length of the cylinder. This straight-line motion must be converted to rotary motion to be usable, so the piston is connected to a crankshaft — a shaft with an offset section — by a connecting rod. The straight-line motion of the piston is converted to rotary motion in much the same way as bicycle pedals are turned.

The cylinders are cast as part of the block if the engine block is iron, or in the case of aluminum alloy, steel liners may be pressed into the block. The tops of the cylinders are sealed by a removable cylinder head, or head for short. A sealing device called a head gasket, which may be made of a variety of materials depending on specific application, fits between the block and head to prevent compression loss from the cylinder. The head gasket also seals coolant and oil passages between the block and the head.

The piston resembles an inverted can. The top of the piston, which is exposed to combustion gases, is the piston crown and the side of the piston is called the skirt. Compression leakage between the piston and

cylinder is controlled by piston rings. Compression rings are specially shaped steel or iron rings that fit into grooves in the piston. The tension caused by compressing the ring into the cylinder allows the compression rings to seal against the cylinder wall and not allow combustion gasses to pass. There is also a ring used to control the oil within the cylinder. This ring acts as a scraper to remove excess oil from the cylinder wall and direct it back into the crankcase. This oil would otherwise be burned in the combustion chamber, causing the engine to smoke profusely and foul spark plugs.

Pistons and rings must be precisely matched and sized to the particular application in which they are being used. Over periods of long usage, cylinders can become worn and misshapen and pistons and piston rings can wear out, causing smoking and loss of performance. The solution to this is to have the cylinders bored oversized and matching oversized pistons and ring sets installed. Since the clearance between the pistons and cylinders is critical, usually just a few thousandths of an inch, it is absolutely necessary that the customer know the bore size of the engine before ordering replacements. Trying to fit an oversized ring onto a standard sized piston to compensate for cylinder wear will not work, and will most likely cause serious engine damage if tried. The original OEM piston may or may not have the size stamped into the crown, usually expressed as 'STD' or standard size. Some aftermarket manufacturers may also stamp their pistons as STD or with the appropriate oversized markings, such as .010



A cylinder block equipped with cylinder liners. (Courtesy: Federal-Mogul Corp.)

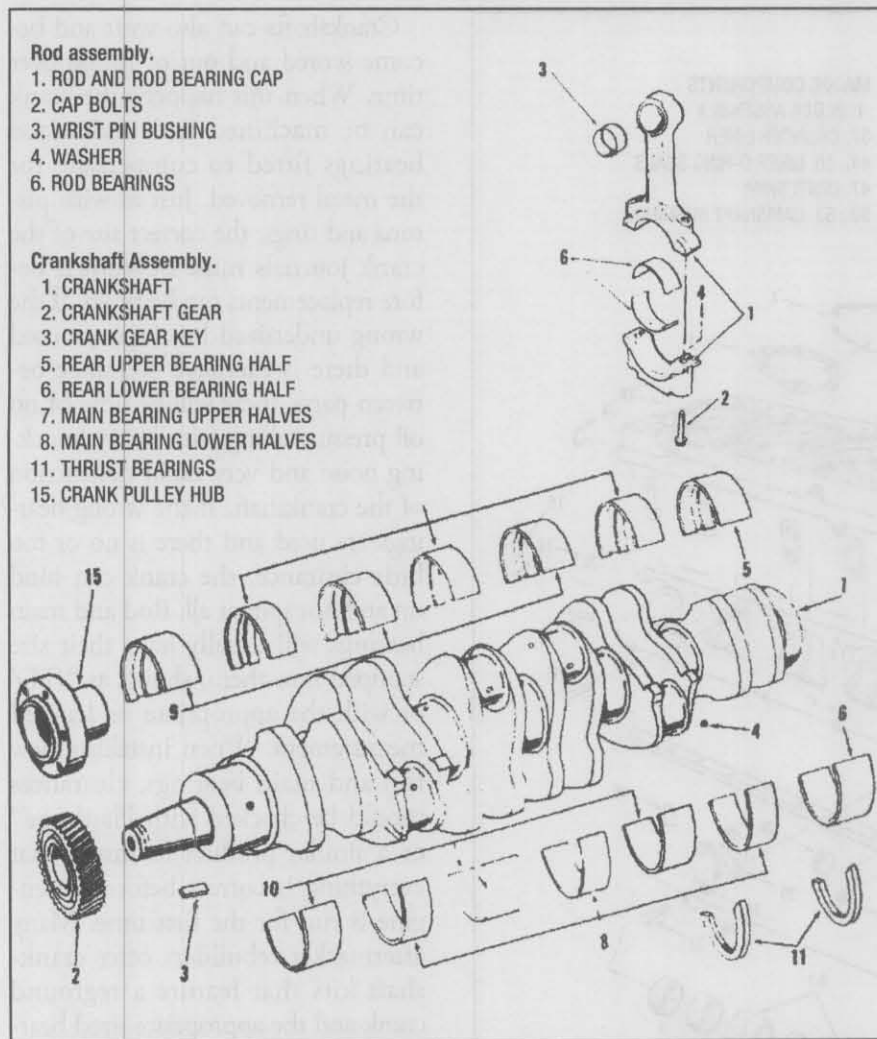
for ten thousandths over. If the customer is at all in doubt, have them accurately measure the cylinder and the piston before making the sale. The consequences of trying to install the wrong sized pistons or rings can be unpleasant and expensive for all concerned.

To allow the connecting rod to swing back and forth (much as your shin does when pedaling a bicycle), it is attached to the piston by a metal dowel called a wrist pin or piston pin. The wrist pin passes through

holes in either side of the piston as well as a hole in the small end of the connecting rod. The big end of the connecting rod attaches to the crankshaft connecting rod journal on the offset part of the crankshaft. To attach to the crankshaft, the big end of the connecting rod is split, with the lower half being bolted to the connecting rod. The crankshaft itself is clamped to the engine block by main bearing caps. These caps hold the main bearings, inserts made of soft metal, in which the crankshaft turns.

Crankshafts can also wear and become scored and out of round over time. When this happens the crank can be machined and undersized bearings fitted to compensate for the metal removed. Just as with pistons and rings, the correct size of the crank journals must be known before replacements can be fitted. If the wrong undersized bearings are used and there is excessive clearance between parts, there will be little or no oil pressure along with heavy knocking noise and very rapid destruction of the crankshaft. If the wrong bearings are used and there is no or too little clearance, the crank can bind up and not spin at all. Rod and main bearings will usually have their size stamped into them, shown as 'STD' or with the appropriate undersized measurement. When installing new rod and main bearings, clearances should be checked with Plastigage™ or a similar product to insure that everything is correct before the engine is run for the first time. Many aftermarket rebuilders offer crankshaft kits that feature a reground crank and the appropriate sized bearings; this can be a good alternative for the customer that does not want to wait while their crank is machined or if it is unusable.

Two final components of the engine block itself need mentioning, the engine mounts and the freeze plugs. The engine assembly must be isolated from the rest of the chassis so that excessive vibrations aren't transmitted throughout the vehicle. This is usually done with a mount made of hard rubber, bonded to and sandwiched between steel plates, that bolts to both the block and frame, although some vehicles may use a liquid filled hydraulically damped mount. In a typical front engine rear drive vehicle, there will be one mount on either side of the block and one or two on the transmission that attach to a frame crossmember. Front wheel drive vehicles with



A crankshaft and connecting rod along with their associated bearings. (Courtesy: Federal Mogul Corp.)

transversely mounted engines use a similar arrangement but terms used to describe the mounts in the catalog may differ. Rather than being listed as left, right, and transmission, the engine mounts may be called left front and rear, with the transmission mount being called the right mount. In addition to the mounts, transverse engine vehicles may also use a torque strut at the top of the engine, which is used to keep the engine from rocking too far over in its mounts as engine speed increases.

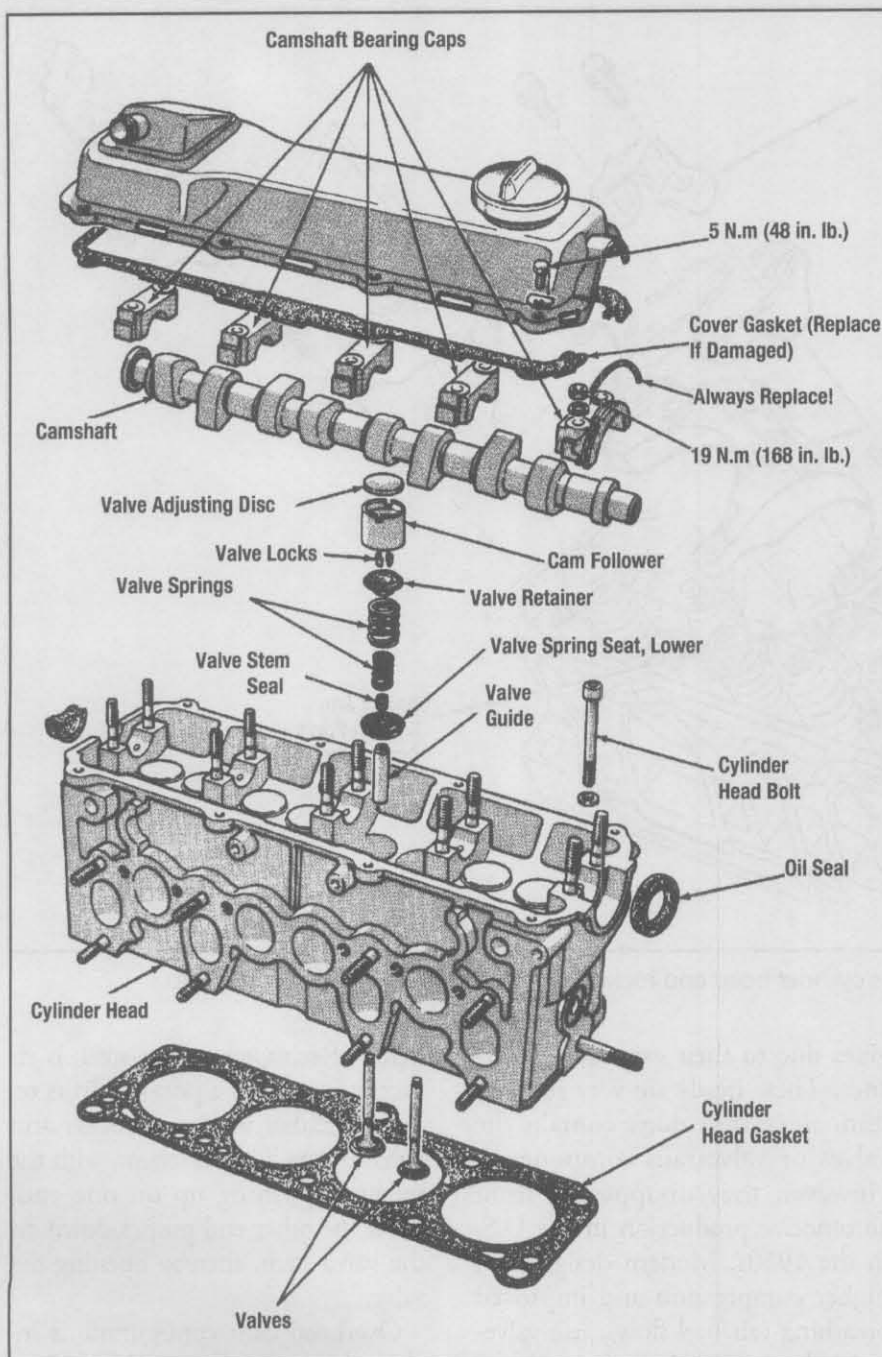
The rubber portion of a motor mount can deteriorate and separate from the metal over time. This can cause excessive vibration, banging noises when the vehicle is shifted

and may even cause the transmission to jump out of gear due to the engine and transmission moving and disturbing the shift linkage. It may also be possible for the fan to cause damage to shrouds or the radiator on a rear drive vehicle if both mounts are broken. Motor mounts should always be checked whenever the engine is removed. DIY customers should be reminded of the need to properly support the engine when changing mounts to avoid injury and facilitate easy removal and installation.

Freeze plugs, or core plugs as they are also called, are installed in holes in the water jacket of the block that are left from the casting process

when the block was made. The term freeze plug is used because the plugs used to seal the holes can push out if the coolant freezes. However, because freezing water expands at an even rate all around its surface, freeze plugs should not be thought of as a safety valve. If a plug was pushed out, an equal amount of expansion took place throughout the cooling system and may have caused cracks elsewhere. Plugs come in a variety of types and sizes, including shallow and deep cup, brass and steel, and rubber expandable ones used for temporary repair. Most often plugs are replaced because they have rusted from the inside out and are leaking. Since access to them can be difficult, especially in transversely mounted engines, removal or lifting of the engine may be required to replace them. This means that it would be foolish to go through all that labor to replace only one, especially when the low cost of each plug is considered.

Since the piston engine has been around for so long the degree of mechanical reliability has increased many times over the years. In the early days of motoring it was not unusual for engines to need rebuilding in as little as 30,000 miles or less due to internal friction of the moving parts. Piston skirts and cylinder walls would become scuffed and scored leading to oil consumption and loss of power. Connecting rod and main bearings would wear, causing excessive clearance between them and the crankshaft. This in turn leads to lower oil pressure at the bearings which only speeds up the wear process and damages the crankshaft as well. Thanks to modern metallurgy and precision manufacturing processes, engines commonly last for 150,000 miles or more before major repairs are needed as long as simple basic maintenance procedures are followed. In the case of engine internals, this means regular oil and filter changes using the right type



Exploded view of an overhead camshaft cylinder head and valve assembly.

of quality lubricant and filters. No other aspect of vehicle maintenance is more critical to a car's longevity than a simple, regularly scheduled oil and filter change.

Camshafts, Valves And Valvetrains

For the engine to operate and produce power it must have more than one stroke, or up and down travel of

its piston, in a complete power cycle. This is how the engine breathes, or facilitates getting the burnt gases out of the cylinder and a new charge of air/fuel in for the next cycle. Except for 2-stroke engines, this is done by valves, which look like mushrooms with flattened caps. The valves extend through holes in the head called ports and are held closed against valve seats by valve springs. Valve

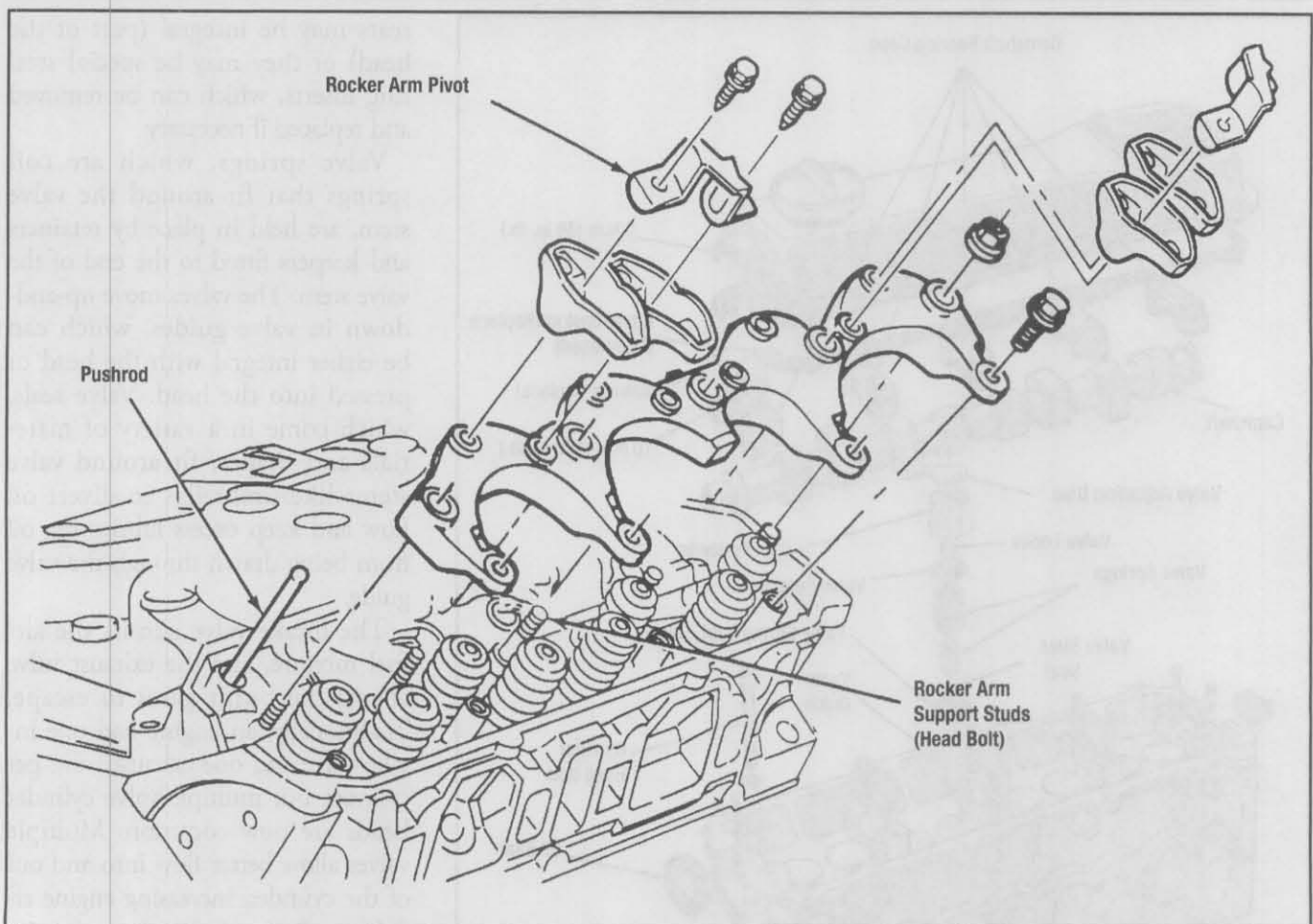
seats may be integral (part of the head) or they may be special steel ring inserts, which can be removed and replaced if necessary.

Valve springs, which are coil springs that fit around the valve stem, are held in place by retainers and keepers fitted to the end of the valve stem. The valves move up-and-down in valve guides, which can be either integral with the head or pressed into the head. Valve seals, which come in a variety of materials and shapes, fit around valve stems like umbrellas to divert oil flow and keep excess lubricating oil from being drawn through the valve guide.

The intake valve admits the air/fuel mixture, and the exhaust valve allows the burnt gases to escape. Traditionally, an engine had one intake valve and one exhaust valve per cylinder but multiple valve cylinder heads are now common. Multiple valves allow better flow into and out of the cylinder, increasing engine efficiency. Some engines have two intake valves and one exhaust valve while others have as many as three intake valves and two exhaust valves. However, four valves per cylinder, with two intake and two exhaust valves, is the most common multi-valve arrangement.

To draw the air/fuel mixture into the cylinder, the intake valve opens as the piston travels downward, creating a vacuum. The intake valve then closes as the piston travels upward and compresses the air/fuel mixture into a small space at the top of the cylinder.

Near the top of the piston's stroke, the fuel is ignited by a spark plug (or in the case of diesel engines, by the heat of compression). This forces the piston down, in the power stroke. As the piston reaches the bottom of its stroke and begins to rise again, the exhaust valve opens, and the rising piston pushes the burnt gases into the exhaust manifold. The exhaust



Exploded view of an overhead valve engine cylinder head and rocker arm assembly. (Courtesy: GM Corp.)

valve then closes, the intake valve opens, and the cycle starts over again.

In practice, engine operating speed requires that the intake valve open before the exhaust valve closes; this is called overlap. Likewise, ignition actually occurs before the piston reaches its highest point — top dead center — so that the air/fuel mixture has sufficient time to burn.

The valves are opened by a shaft with eccentric lobes on it, which is called a camshaft. The valves are opened either directly or by a combination of pushrods and/or rocker arms. The assortment of parts that connect the camshaft to the valve is called the valvetrain.

Early side valve engines placed the valves in the engine block alongside the cylinder, opening into a cavity that extended over the cylinder. These are usually called flathead en-

gines due to their external appearance. These heads are very flat and thin, since they don't contain the valves or valvetrain components. However, they disappeared from automotive production in the U.S. in the 1950s. Modern designs, for higher compression and improved breathing (air/fuel flow), use valve-in-head configurations. Some intermediate designs, as used by Jeep, had one valve in the head and one in the block; these are called F-head engines.

Valve-in-head designs are divided into pushrod and Overhead Cam (OHC) designs. The pushrod engine has its camshaft located in the block. Each cam lobe pushes a lifter, which then pushes a pushrod (a thin metal rod that extends from the lifter into the head) that fits into one end of a rocker arm. Each rocker arm,

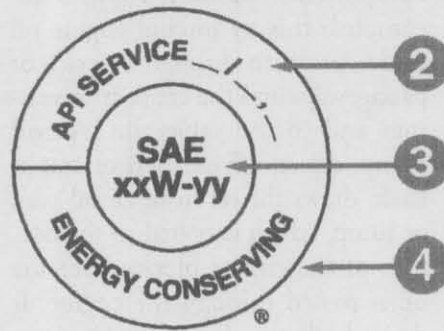
made of stamped or cast steel, is either mounted on a post or pivots on a shaft. Either way, each rocker arm behaves much like a seesaw, with the pushrod pushing up on one end, while the other end pushes down on the valve stem, thereby opening the valve.

Overhead cam configurations include both Single Overhead Cam (SOHC) and Double Overhead Cam (DOHC) versions. Note that the overhead cam designation refers to cams-per-head. Thus, a DOHC in-line engine — either four- or six-cylinder — has two camshafts. A DOHC V6 or V8 has four camshafts.

Overhead cam engines may open valves directly, with only a follower between the valve stem and the camshaft, or by rocker arms. The rocker arm OHC engine is usually a single



API® Certification Mark
"Starburst"



API® Service Symbol
"Donut"



API® Service Symbol "Donut"
with CI-4 PLUS

API's Service Symbol and Certification Mark identify quality engine oils for gasoline- and diesel-powered vehicles. Oils displaying these marks meet performance requirements set by U.S. and international vehicle and engine manufacturers and the lubricant industry. More than 500 companies worldwide participate in this voluntary program, which is backed by a marketplace sampling and testing program.

1. Starburst: An oil displaying this mark meets the current engine protection standard and fuel economy requirements of the International Lubricant Standardization and Approval Committee (ILSAC), a joint effort of U.S. and Japanese automobile manufacturers. Most automobile manufacturers recommend oils that carry the API Certification Mark.

2. Performance Level:

Gasoline engine oil categories (for cars, vans, and light trucks with gasoline engines): Oils designed for gasoline-engine service fall under API's "S" (Service) categories. See reverse for descriptions of current and obsolete API service categories.

Diesel engine oil categories (for heavy-duty trucks and vehicles with diesel engines): Oils designed for diesel-engine service fall under API's "C" (Commercial) categories. See reverse for descriptions of current and obsolete API service categories.

3. Viscosity Grade: The measure of an oil's thickness and ability to flow at certain temperatures. Vehicle requirements may vary. Follow your vehicle manufacturer's recommendations on SAE oil viscosity grade.

4. Energy Conserving: The "Energy Conserving" designation applies to oils intended for gasoline-engine cars, vans, and light trucks. Widespread use of "Energy Conserving" oils may result in an overall savings of fuel in the vehicle fleet as a whole.

5. CI-4 PLUS: Used in conjunction with API CI-4, the "CI-4 PLUS" designation identifies oils formulated to provide a higher level of protection against soot-related viscosity increase and viscosity loss due to shear in diesel engines. Like Energy Conserving, CI-4 PLUS appears in the lower portion of the API Service Symbol "Donut."

more frequent preventive maintenance replacement; this is often required at 60,000 miles or whenever the cylinder head or belt is removed. A new belt should be installed if the belt shows obvious signs of wear, deterioration or contamination. However, the belt should also be replaced even if wear is not visible, since visible wear does not always precede failure. Failure to replace the belt can result in belt breakage, which can cause internal damage to the engine. On non-freewheeling or interference engines, there is a high degree of danger when timing belts are not replaced as scheduled. If the belt breaks while the engine is running, serious valve, piston, valvetrain and other engine damage will occur due to the pistons hitting the valves. On a freewheeling engine, if the timing belt breaks, the valves will not touch the pistons.

Certain cylinder head and valvetrain components are not items usually purchased by the average DIY customer. Parts such as valve guides and valve seat inserts require specialized equipment to install and machine. If your store performs machine shop services or if you are a supplier to one you may be asked for these types of parts, otherwise you may never have an occasion to look them up. Other valvetrain parts

overhead cam design, with the camshaft at the far end of the rocker arm (away from the valve stem), actuating the rocker like a pushrod. Another rocker arm OHC arrangement has the rocker arm positioned underneath the camshaft, with the cam lobe pressing down the rocker arm in the middle. With one end of the rocker arm mounted on a post (or stud), the other end then must press down on the valve stem, opening the valve. The camshafts in DOHC engines typically actuate the valves directly, although some type of cam follower is used between the valve stem and camshaft.

Camshafts must rotate to operate, and can be driven by timing gears, timing chains or timing belts. Gears are only used in inline pushrod type overhead valve engines, where the camshaft is located next to the crankshaft. Overhead valve engines typically use timing chains. Some overhead cam engines use timing chains, while others use timing belts. These fabric/rubber belts, sometimes called cogged timing belts, are toothed or cogged so that the camshaft remains in proper alignment with the crankshaft.

Though timing chains wear (or stretch), timing belts are subject to

such as camshafts, lifters or followers, rocker arms and pushrods are more commonly replaced by professional installers and are not too difficult for the more advanced DIY customer. The most common reason for valve and guide replacement other than damage due to a broken belt or chain comes from wear, just as in the lower half of the engine. As the valves move up and down in the guides, wear will occur. As the clearance between valve and guide increases it can allow too much oil to be drawn down the guide and into the combustion chamber. Once this happens excessive carbon from the burnt oil can build on the piston and valves, which in turn can lead to leaking valve seats and loss of compression and power.

When selling any internal engine parts, make sure you have all the necessary information before beginning. This includes engine numbers and VIN numbers, as it is not unusual for a vehicle to have had the engine changed, and the numbers no longer agree with each other. Related sales of internal components are a natural due to the fact that most parts ride and move on another part. So if one part is worn out, chances are that the related component is also close to wearing out. For example, it would be foolish to change a camshaft without changing the lifters or followers. Some parts must be replaced when changing others, such as cylinder head bolts on torque-to-yield applications, when changing a head gasket. The parts catalog will often give recommendations and installation tips for you to pass along to the customer. Also, don't forget to ask about things such as parts cleaners and gasket sealers.

Lubrication Systems

Internal engine parts operating at high temperatures and pressures must have some sort of lubrication to both cool and prevent seizing of

components. Modern engines accomplish this by forcing engine oil under pressure through a series of passageways into the crankshaft bearings and to the valvetrain. An oil pump, driven off the cam or crankshaft, draws the oil from an oil pan, or sump, which is bolted to the bottom of the engine block. After the oil is passed through the engine, it drains back into the pan and is circulated again.

Since oil is the lifeblood of an engine, an oil filter is provided to rid the oil of contaminants that would decrease its effectiveness and cause engine wear. The most common automotive filter is a completely disposable unit that screws onto the engine. It contains a filter element through which all oil passes, plus a bypass valve in case the filter becomes clogged. Some filters have anti-drainback valves, which keep them full of oil when the engine is shut off so that full lubrication is available sooner on start-up. In addition to the petroleum base stock, engine oils contain various additives to reduce wear and help keep contaminants in suspension. With use these additives break down and stop working, and in addition they can form sludge inside the engine that can have very harmful effects. For this reason it's important that engine oil be changed frequently and the proper grade of oil used.

Modern engines use oil that is very different from what was common even a few years ago. Engine oils used must be in accordance with manufacturers' specifications as to viscosity and rated service. All motor oil containers should have an American Petroleum Institute (API) rating label on them that signifies what type of service they are intended for. Oils rated for gasoline or other engines that use a spark ignition will have a rating starting with the letter S followed by another letter designating other attributes. These other

attributes are things such as detergent properties or shear resistance that may be mandated or required by the government or manufacturer. Motor oil for use in diesel engines is rated in the same way but the letter S is replaced with a C, which stands for compression ignition.

In the quest for cleaner burning, more fuel-efficient engines, the demands placed on lubricating oil have increased substantially. Older oils such as those used prior to 1988 have an API rating of SF or below while the current rating for new engines is SJ (since 1997) or beyond (SM for 2005). In most cases an older engine can use oil specified for current engines but not always the other way around.

Viscosity or the ability to flow is the other critical factor to consider when choosing oil. Viscosity is expressed as a number such as SAE5W or SAE40W, and when oil meets a multi-viscosity specification it is expressed as 10W30 or 15W40, the W signifying that it is suitable for winter use. Some people may refer to this rating as oil weight also.

In addition to petroleum based oils, synthetics and synthetic blends are also available and these use the same API classifications and weight ratings as regular oils. Full synthetic oils are derived from vegetable or animal oils and combined with other compounds, and these are usually only found in industrial applications. As far as automotive use goes just about all oils are refined from mineral (petroleum) oils. The difference is in the way they are refined and how much of the finished product is base stock and how much is additive; full synthetics use a much more refined base stock and a higher percentage of additives than semi-synthetics. Pure synthetics such as castor oil will not mix with mineral based oils, but any type of mineral based, semi or full synthetic as well as conventional oil, can be mixed with no

Gasoline Engines		
Category	Status	Service
SM	Current	For all automotive engines currently in use. Introduced November 30, 2004, SM oils are designed to provide improved oxidation resistance, improved deposit protection, better wear protection, and better low-temperature performance over the life of the oil. Some SM oils may also meet the latest ILSAC specification and/or qualify as Energy Conserving.
SL	Current	For 2004 and older automotive engines.
SJ	Current	For 2001 and older automotive engines.
SH	Obsolete	For 1996 and older engines. Valid when preceded by current C categories.
SG	Obsolete	For 1993 and older engines.
SF	Obsolete	For 1988 and older engines.
SE	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1979.
SD	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1971. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SC	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1967. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SB	Obsolete	CAUTION—Not suitable for use in gasoline-powered automotive engines built after 1963. Use in more modern engines may cause unsatisfactory performance or equipment harm.
SA	Obsolete	CAUTION—Contains no additives. Not suitable for use in gasoline-powered automotive engines built after 1930. Use in modern engines may cause unsatisfactory engine performance or equipment harm.

Note: API intentionally omitted "SI" and "SK" from the sequence of categories. For more information about API's Engine Oil Program, visit our website at www.api.org/eoics.

Diesel Engines		
Category	Status	Service
CI-4	Current	Introduced in 2002. For high-speed, four-stroke engines designed to meet 2004 exhaust emission standards implemented in 2002. CI-4 oils are formulated to sustain engine durability where exhaust gas recirculation (EGR) is used and are intended for use with diesel fuels ranging in sulfur content up to 0.5% weight. Can be used in place of CD, CE, CF-4, CG-4, and CH-4 oils. Some CI-4 oils may also qualify for the CI-4 PLUS designation.
CH-4	Current	Introduced in 1998. For high-speed, four-stroke engines designed to meet 1998 exhaust emission standards. CH-4 oils are specifically compounded for use with diesel fuels ranging in sulfur content up to 0.5% weight. Can be used in place of CD, CE, CF-4, and CG-4 oils.
CG-4	Current	Introduced in 1995. For severe duty, high-speed, four-stroke engines using fuel with less than 0.5% weight sulfur. CG-4 oils are required for engines meeting 1994 emission standards. Can be used in place of CD, CE, and CF-4 oils.
CF-4	Current	Introduced in 1990. For high-speed, four-stroke, naturally aspirated and turbocharged engines. Can be used in place of CD and CE oils.
CF-2	Current	Introduced in 1994. For severe duty, two-stroke cycle engines. Can be used in place of CD-II oils.
CF	Current	Introduced in 1994. For off-road, indirect-injected and other diesel engines including those using fuel with over 0.5% weight sulfur. Can be used in place of CD oils.
CE	Obsolete	Introduced in 1985. For high-speed, four-stroke, naturally aspirated and turbocharged engines. Can be used in place of CC and CD oils.
CD-II	Obsolete	Introduced in 1985. For two-stroke cycle engines.
CD	Obsolete	Introduced in 1955. For certain naturally aspirated and turbocharged engines.
CC	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1990.
CB	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1961.
CA	Obsolete	CAUTION—Not suitable for use in diesel-powered engines built after 1959.

These charts illustrate the API Service Symbols and what the various designations mean.
(Courtesy: American Petroleum Institute-API)

adverse effects.

You may also be asked for oil specific to high mileage engines. Usually these oils have additives that help to reduce oil consumption due to worn piston rings or leaking seals. These additives may, however, negate any energy conserving properties that the oil it's replacing has. It may also not be

of the correct API classification for the engine it's to be used in so always make sure.

If you are unsure of what oil to use or recommend don't ever guess! Lubricating properties are being updated and revised constantly and the use of the wrong oil can cause significant and costly engine damage in a short time. Oil recommendations

may be found in owner's manuals or labels on the engine or other underhood areas and possibly even on the oil level dipstick.

Be aware that even though a filter may fit on an engine, its internal parts and function may not be appropriate for that application. Always follow the manufacturer's application recommendations.

Used oil filters are considered hazardous materials and in some cases you may be required to provide disposal for them. Make sure they are fully drained before final disposal. Used motor oil has also been determined to be a cancer-causing agent when exposed to the skin for long periods of time. Because of this the use of latex or nitrile gloves is recommended when performing oil changes or handling used oils.

COOLING SYSTEMS

The modern combustion engines used in today's vehicles generate a tremendous amount of heat. A gasoline engine's combustion chamber can reach temperatures above 4500°F. Approximately a third of this combustion heat is actually used to power the vehicle; another third passes through the exhaust; and the last third is the responsibility of the cooling system.

In past years, there have been two types of engine cooling systems: water-cooled and air-cooled. The Volkswagen Beetle is the best example of a vehicle with an air-cooled engine. The basic parts of an air-cooled system are the air intakes, fan, cooling fins, exhaust duct and thermostatic air control. Engine cooling is accomplished by a fan sending air through ducts and around cooling fins on most external parts of the engine. Today's newer engine designs and tighter emissions standards make air cooling impractical, and all modern engines use a liquid based cooling system.

To successfully help today's customers requires a thorough knowledge of the cooling system. Aluminum cylinder heads, smaller radiators, emission controls, more accessories and reduced air flow over the radiator all make it critical for the cooling system to work properly. The condition of the radiator cap, radiator, water pump, thermostat and coolant all must be given greater

consideration than in earlier years.

The engine block and head have cast-in passages through which coolant, usually a 50/50 mix of water and ethylene or propylene glycol, circulates. These passages are connected by radiator hoses to a radiator, which consists of a network of thin tubes (usually aluminum) connecting end tanks, either at the top and bottom or at each side of the radiator. The tubes are covered with thin fins. The coolant, which is heated by the engine's combustion, flows through the radiator, which dissipates much of the heat.

Early cars used the thermosyphon concept to circulate coolant in the cooling system. Since cool dense water sinks and hot, less-dense water rises, coolant would circulate without the need for a pump. Modern engines, however, use a water pump to make sure adequate coolant circulation occurs. The water pump is typically mounted at the front of the engine and driven from a crankshaft pulley by a serpentine or V-belt. Coolant is usually circulated up through the engine and down through the radiator, although there are side flow radiators, and reverse flow circulation on some engines.

Water pumps are replaced for one of two reasons, either they leak or the impeller shaft bearings go bad. If the seal on the impeller shaft goes bad coolant will leak out around the shaft or from a weep hole in the pump casting. Bearings can go bad from lubricant being washed out due to a leaking seal or from the drive belt being over tightened.

While air flow over the radiator is usually adequate while the car is in motion, idling or driving at low speed could result in inadequate air flow for complete cooling. Therefore, fans are used. By tradition, a fan is mounted on the water pump shaft (which is why the belt turning the water pump is often called the fan belt). This fan turns at the same

speed as the water pump. While this is simple, cheap and generally effective, it is also a power drain, as the fan is always churning up the air whether needed or not. Therefore, a spring clutch or silicone fluid clutch is used to allow thermostatic control of the cooling fan, allowing it to free-wheel when the temperature is cool enough. On most newer vehicles, and on all cars where the engine is mounted transversely, electric fans are mounted directly on the radiator and controlled by electric thermostats mounted in the coolant stream. Fans are often surrounded by a shroud, or large duct, that increases the fan's efficiency by concentrating the air flow across the radiator.

The common failure of thermostatic fan clutches is that they no longer 'lock up' and cause the fan to spin when there is low air flow across the radiator, although they can also freeze in the locked up position and cause the fan to turn full time. Symptoms of a clutch that fails to lock up are overheating at low speeds, especially if the vehicle is under a heavy load such as towing or carrying a snowplow. Conversely, a fan that doesn't declutch can cause excessive engine noise and vibration. The two most common causes of electric cooling fan failure are a bad fan motor or the thermostat that controls it. If no power is present at the fan motor the switch can be tested by jumping across the terminals to bypass it, if no power is present at the switch then the problem lies in the wiring or with a fan motor relay if one is used. If power is present at the fan motor but it doesn't work it's pretty safe to assume that the motor is bad.

The fan belt, or accessory drive belt, is more than just a part of the cooling system, but is often listed in that group. Belts are also used to drive the power steering pump, alternator, AIR (Air Injection Reactor) pump, and air con-

ditioning compressor. With a V-belt system, multiple belts are used with each ancillary component, with each also having its own method for tensioning. V-belts are typically 7/16-in. to 9/16-in. wide and about 5/8-in. thick, and the method most often used to adjust them is to

mount the driven component on a pivot and move it in or out to get the proper tension.

V-belts work well enough but they generate a lot of heat, which can cause them to fail. Also, the need to provide belts for every driven component under the hood led to the

development of the microV, or serpentine, belt. Serpentine belts are thin flat belts, wider than a V-belt, and have a series of tiny V grooves on the bottom side. These small grooves engage with small grooves in the pulleys of the driven components to turn them just as a stan-



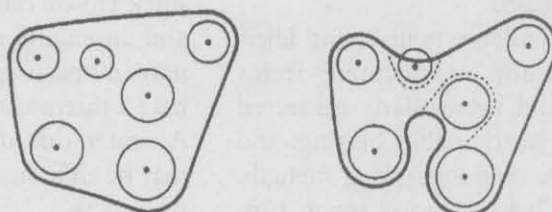
The world's most trusted name in belts and hose.

Micro-V® (Serpentine) Belt Routing Diagrams

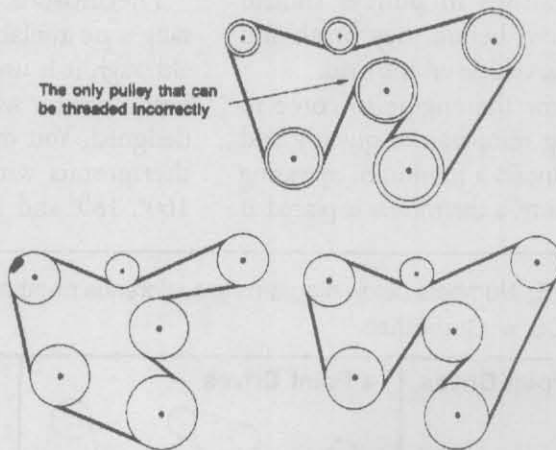
Gates recognizes serpentine belt installation can be a problem without routing diagrams. Gates has the solution. The counterman has circled the diagram that applies to your particular application ... you now have an easy-to-follow routing diagram. You'll want to keep this sheet for future reference.

Installation Tips

1. The grooved side of the belt meshes with pulley grooves.
2. The belt basically encircles the pulley system, and is drawn in and looped around smooth pulleys.
3. Usually there is only one pulley that can be threaded incorrectly. That pulley is always near the center of the pulley group, and is always a smooth pulley (no grooves).
4. If the belt appears too short or long to be installed, it is probably threaded the wrong way around the pulley mentioned in Tip 3.
5. Belt should be seated into pulley grooves and spans free of contact with engine components.



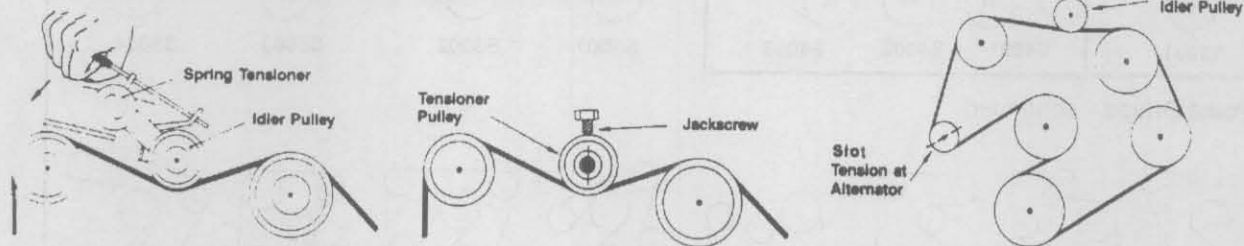
The only pulley that can be threaded incorrectly



If this routing doesn't work ...

try this.

Typical Methods of Tensioning Serpentine Belts



Belt installation chart that is handed out with the purchase of a new serpentine belt. These can be invaluable to the customer with a broken belt. (Gates Rubber Co.)

standard V-belt would. Since they are thinner they dissipate heat faster, run much cooler, and last up to 25% longer than a V-belt. It is also possible to run all of the driven components with one belt due to their flexibility. A typical installation has one belt running everything, with idler pulleys used to route the belt and a spring-loaded tensioner to maintain constant adjustment. The tensioner has the added benefit of keeping the proper belt tension on every driven component. Over tightening a V-belt can cause premature bearing wear in pumps and alternators. This is avoided with a serpentine belt but it is essential that the belt be the correct length and properly routed when installed.

Belts, tensioner pulleys, and idlers are common replacement items and should be regularly inspected for wear in the pulley bearings and for proper tensioner spring strength. Cracked belts or noisy rough running bearings in pulleys should be replaced before they break and strand the vehicle on the road.

To allow the engine to come to operating temperature quickly and then maintain a minimum operating temperature, a thermostat is placed at

the coolant exit from the engine. The thermostat remains closed until a specific temperature is reached; the thermostat then opens and allows coolant to circulate to the radiator and cool the engine. When the thermostat is closed, a bypass valve, which allows coolant to return directly to the water pump, may recirculate coolant, or it may be recirculated from the head to the block via an opening provided for that purpose.

Thermostats are not usually replaced until they fail, but some technicians will replace them as part of an overall cooling system service when changing the water pump or when major internal engine work has been done. A thermostat that is stuck closed can cause overheating, and an engine that does not reach normal operating temperature could have a thermostat that is stuck open. A heater that doesn't get very hot may be an indication of a stuck open thermostat.

Thermostats of different heat ranges are available for most engines, although it is usually best to use the heat range for which the engine was designed. You may find listings for thermostats with temperatures of 160°, 180° and 195°F. These are the

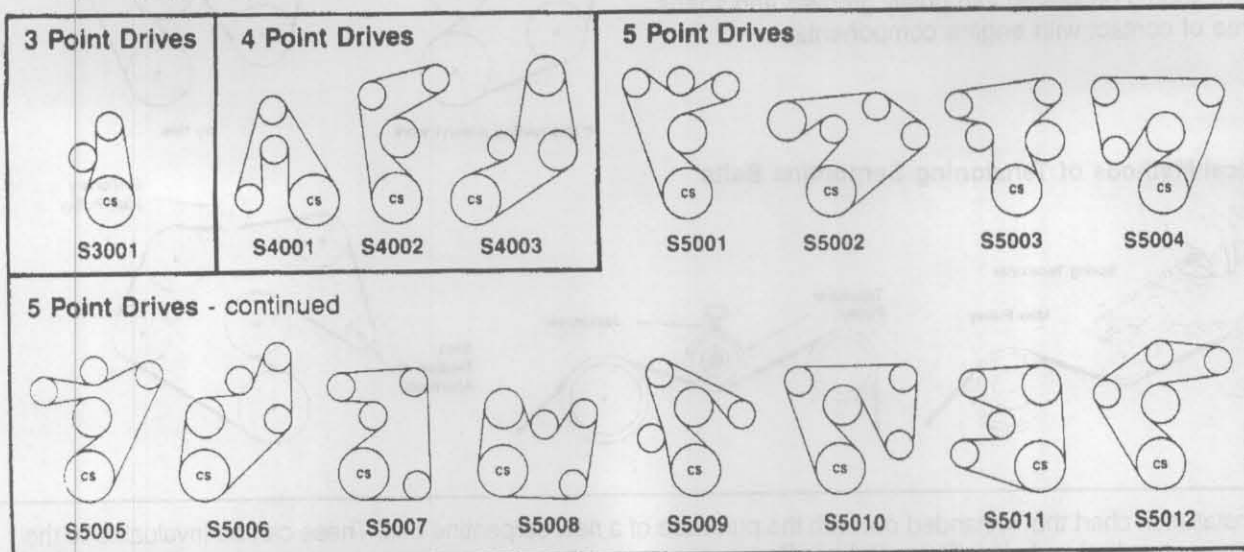
temperatures at which the thermostat begins opening; they open fully at about 20° above the temperature rating. Using an incorrect heat range thermostat may cause drivability problems, since the ECM may not allow the fuel injection or emission systems to go into normal operation if it thinks the engine is not up to operating temperature.

Because a higher atmospheric pressure raises the boiling point, modern engines use pressurized cooling systems. These systems are at normal atmospheric pressure when cool, but because they are sealed, the pressure increases as the temperature rises. Operating under extreme conditions — such as under heavy load, in high ambient temperatures, or at a high elevation where the atmospheric pressure and the boiling point are lower, can boil off the coolant if the system is not pressurized. A pressurized system can raise the boiling point in the system up to 250°F.

The system is not completely sealed, however. The radiator cap is vented with a pressure relief valve that keeps the system from exploding if pressure builds too high. When the relief valve opens it will allow coolant to flow into an overflow

NOTE: Numbers below diagrams are reference numbers not belt part numbers.

CS = Crankshaft



reservoir. As the engine cools, the coolant is drawn back into the radiator from the overflow by vacuum created within the radiator. Typical release pressure is 15 psi. The cap should not be removed when the engine is hot, as the decrease in pressure could cause sudden boiling, and the violent escape of super-hot steam and coolant can cause burns. Unless the system has been opened for service, or a large amount of coolant has been lost, the fluid level is usually checked and adjusted in the overflow reservoir.

Cooling system sales are probably the most common underhood items you will encounter after basic tune-up materials, so you should be prepared for them. Most water pumps are available as new or rebuilt so you can offer your customer a choice in price and perceived quality. Gaskets, hose clamps, belts, cooling system flush, and antifreeze are all natural add on items that will make the job easier for the customer and more profitable for you.

You may also have a choice of antifreeze types, such as traditional ethylene glycol or the long life propylene glycol. These can often be distinguished by the color, with ethylene being green, and propylene being red or orange. While mixing the two may not affect cooling ability, it will negate the long life capability of propylene glycol. There are also some brands of environment friendly non-toxic coolant on the market. Ethylene glycol is highly toxic, and has a sweet smell and taste, so some animals may try to drink it if left in an open pan or dumped on the ground. Remind your customer that it is considered hazardous waste and should be treated as such.

Finally, be sure to remind the DIY customer of the safety aspects of working on a hot cooling system, and the possibility of severe burns if they are not careful. You could also remind them that the best thing they

can do to keep the cooling system in good shape is a periodic draining and flushing, and refilling with fresh coolant.

FUEL SYSTEMS

Fuel is supplied to gasoline engines by either a carburetor, or fuel injection system. All diesel engines are fuel injected. The carburetor is no longer installed on vehicles manufactured for use in the U.S. due to fuel efficiency and emissions concerns, but many vehicles equipped with carburetors are still in use. A carburetor uses vacuum to draw air through a restrictor called a venturi, where gasoline is pulled into the air stream and atomized. Very little gasoline is mixed with air; by volume the ratio is about 9,000:1; by weight, about 14:1 for the ideal air/fuel mixture.

Working from the combustion chamber out, the first component we find in the fuel system is the intake manifold. The intake manifold's function is to provide a passageway into the combustion chamber for the air or air/fuel mixture. The manifold is bolted to the head and the carburetor or throttle body is bolted to the intake end of the manifold. Intake manifolds will only require replacement if they become cracked, or the mating surfaces become warped or otherwise damaged beyond the point of being planed back to a flat condition.

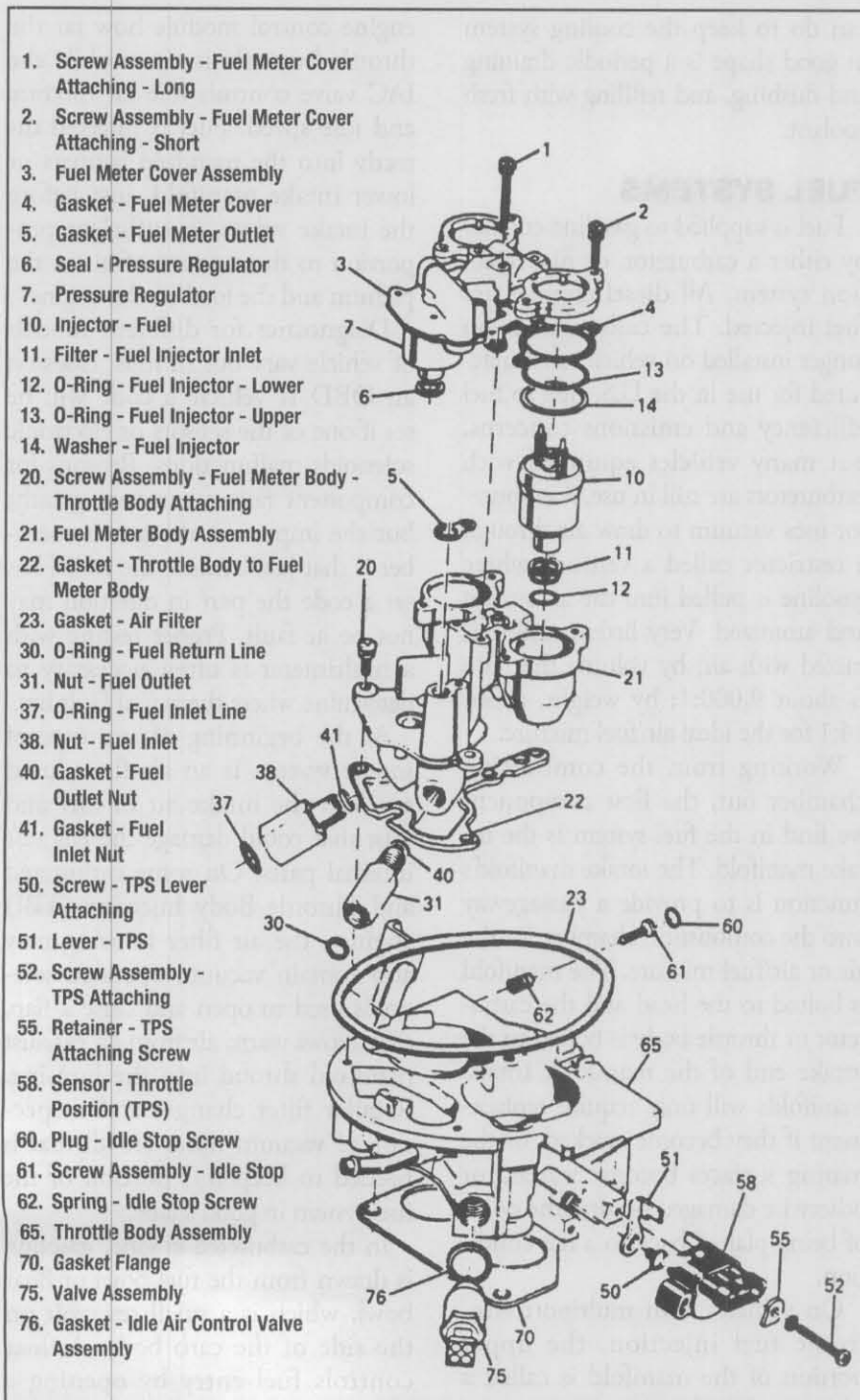
On vehicles with multiport electronic fuel injection, the upper portion of the manifold is called a plenum chamber or upper intake manifold; it is only an air chamber, and no fuel is admitted into the system at this point. Air is admitted into the plenum by a butterfly valve linked to the throttle pedal in the vehicle. As the pedal is depressed, the valve opens and admits more air into the engine. This is usually where the Throttle Position (TP) sensor and Idle Air Control (IAC) valve are found. The TP sensor tells the

engine control module how far the throttle butterfly is open while the IAC valve controls idle air mixture and idle speed. Fuel is injected directly into the manifold runners or lower intake manifold, just before the intake valves, in sufficient proportion to the amount of air in the plenum and the load on the engine.

Diagnostics for different models of vehicle vary but in most cases on an OBD II vehicle a code will be set if one of the sensors or electronic solenoids malfunctions. Reasons for component failure can vary greatly, but the important thing to remember is that just because the ECM has set a code the part in question may not be at fault. Proper testing with a multimeter is often necessary to determine where the actual fault lies.

At the beginning of any type of intake system is an air filter, used to clean the intake air of dirt and dust that could damage the engine's internal parts. On some carbureted and Throttle Body Injection (TBI) engines, the air filter housing may also contain vacuum operated solenoids used to open and close a flap, that allows warm air from an exhaust manifold shroud into the housing. Regular filter changes and inspection of vacuum hoses are all that is needed to keep this portion of the fuel system in good shape.

In the carbureted engine, gasoline is drawn from the fuel bowl or float bowl, which is a small reservoir on the side of the carb body. A float controls fuel entry by opening a needle valve when the float falls (as fuel is used), then closing it when the appropriate level is reached. To regulate engine speed, which would otherwise run at maximum, a throttle plate is located below the fuel discharge and is connected to the throttle pedal in the vehicle. The plate is the same diameter as the carburetor throat and is mounted on a shaft, which runs across the carburetor throat. The shaft can be turned



Exploded view of a typical TBI (Throttle Body Injection) system on a GM vehicle. TBI fuel injection systems are similar in appearance to traditional carburetors.

to close the plate, restricting the air/fuel mixture reaching the engine and thereby slowing it, or opened to allow the engine to run at maximum power and speed.

This basic carburetor has a number of shortcomings. One is that the engine requires a richer mixture (more

fuel in the air/fuel mixture) to start when cold. This problem is solved by placing a second throttle plate — called a choke — above the main fuel discharge. This increases the vacuum in the carburetor throat, which draws more fuel into the air stream without opening the throttle plate.

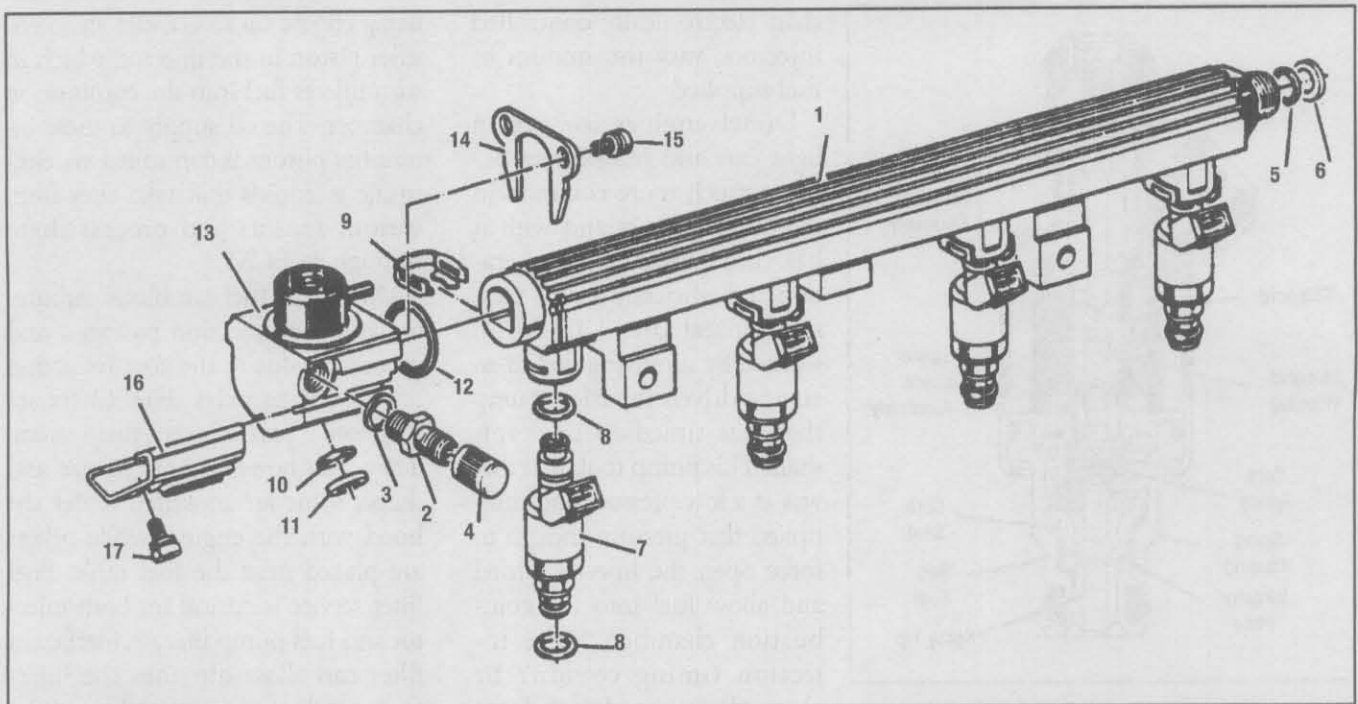
Most carburetors contain a number of circuits, including the idle circuit, low-speed circuit, and high-speed circuit. Metering rods, vacuum diaphragms and a number of bleeds and vents adjust the fuel mixture to compensate for the demands of a wide range of engine operating situations.

Sudden opening of the throttle will reduce vacuum, temporarily reducing the amount of fuel drawn into the air stream, and cause a lean condition and flat spot. This condition is avoided by using an accelerator pump, which squirts a stream of fuel into the carburetor throat, allowing the engine to build vacuum as the engine speed increases.

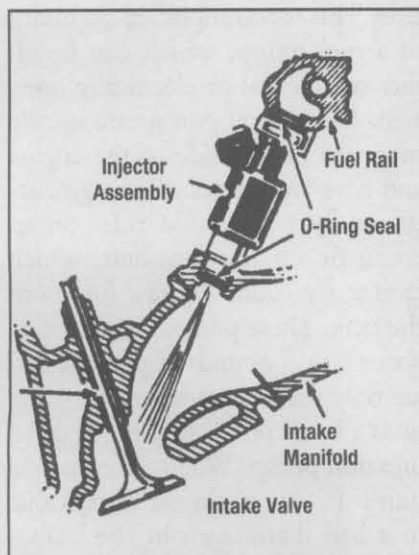
The final adaptation of the carburetor occurred in the early 1980s with the development of the feedback carburetor. This is a basic carburetor to which electronic controls have been added. The air/fuel mixture is varied based on computer interpretation of data from electronic sensors. (A sensor is a device that reads a specific condition, such as temperature, and then relays the information to the computer, which uses the information to adjust various vehicle functions.)

The common failure point/ enemy of all carburetors is dirt from unfiltered air entering the carb throat, and sludge and dirt buildup from fuel residue. Some carburetors can also suffer from worn throttle shaft bushings, which allow air to leak in below the throttle plate and fuel to leak out.

As complex as the modern carburetor had become, it was not sufficiently precise enough to control fuel for low tailpipe emissions. Electronic fuel injection began appearing in the 1970s on some vehicles and is now used on all emissions-controlled engines in the United States. Electronic fuel injection uses a computer, or ECM, to calculate how much fuel will be injected into the air intake for



Exploded view of a fuel rail assembly: 1–Fuel Rail Assy.; 2–Fuel Pressure Connection Assy.; 3–Fuel Pressure Connection Assy. Seal; 4–Fuel Pressure Connection Cap; 5–Fuel Inlet Tube Seal; 6–Fuel Inlet Tube Seal Retainer; 7–MPFI Injector Assy.; 8–Injector O-Ring Seal; 9–Injector Retainer Clip; 10–Fuel Return Tube Seal; 11–Fuel Return Tube Seal Retainer; 12–Rail-To-Regulator Base Seal; 13–Pressure Regulator Assy.; 14–Regulator Retainer; 15–Pressure Regulator Screw; 16–Regulator; 17–Return Tube Retainer.



Typical port fuel injector mounting location.

efficient operation and minimal exhaust emissions. The computer uses data from various sensors, including an intake air flow sensor (MAF or mass air flow), coolant temperature sensor, ambient air temperature sensor, throttle position sensor, and

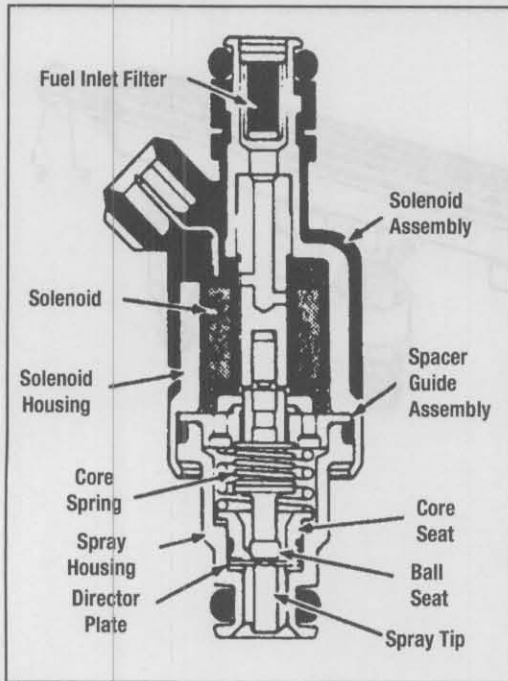
sensors that measure oxygen in the exhaust. Note that not all of these sensors may be used; the type of sensor used may vary (there are several ways to measure intake air flow, for example); and sensors other than those mentioned here may be used.

There are two common types of electronic fuel injection: throttle body injection and multiport injection. Throttle Body Injection (TBI) places one or more injectors in a carburetor-like body that also contains a throttle plate, and this unit is mounted atop the intake manifold just like a traditional carburetor. As conditions dictate, the injectors spray an appropriate amount of fuel into the incoming air stream to meet engine demand. Multiport injection has individual injectors in each intake port, usually right by the intake valves, and as engine load increases, the fuel control programming portion of the computer signals the injectors to increase fuel delivery. In both cases the injectors are noth-

ing more than electronic solenoids that open to allow the fuel, which is under pressure from the fuel pump, to be sprayed into the manifold.

In a multiport system, fuel is supplied to the injectors through a fuel rail, which is connected to the fuel pump. The fuel rail also contains a fuel pressure regulator. The pump draws fuel from the tank and supplies it to the fuel rail at a steady rate and higher pressure than the injectors may require. Since the vehicle will use this fuel at varying rates depending on engine load, the regulator opens or closes to maintain the pressure required for proper injector operation. Excess fuel is sent back to the tank via the fuel return line. Residual pressure can remain in the fuel lines after the vehicle is shut off, so care must be taken when disconnecting them in order to avoid fuel spray.

Mechanical fuel injection was used on most diesel engines and, in the past, has been used on some gasoline engines. Mercedes-Benz,



Cutaway view of a fuel injector assembly.

BMW and Chevrolet used mechanical fuel injection for limited-production, high-performance gasoline engines. Mechanical fuel injection differs from electronic fuel injection in that mechanical, rather

than electronically controlled injectors, vary the amount of fuel supplied.

Diesel engines for use in light cars and trucks have become much more common in the last few years and with it has come advances in operation and efficiency. In the past, mechanical diesel injection worked by supplying fuel to an engine driven injection pump that was timed to the camshaft. This pump took fuel that was at a low pressure and multiplied that pressure enough to force open the injector pintel and allow fuel into the combustion chamber. Since injection timing couldn't be changed to properly suit loads the actual setting was a compromise between power and

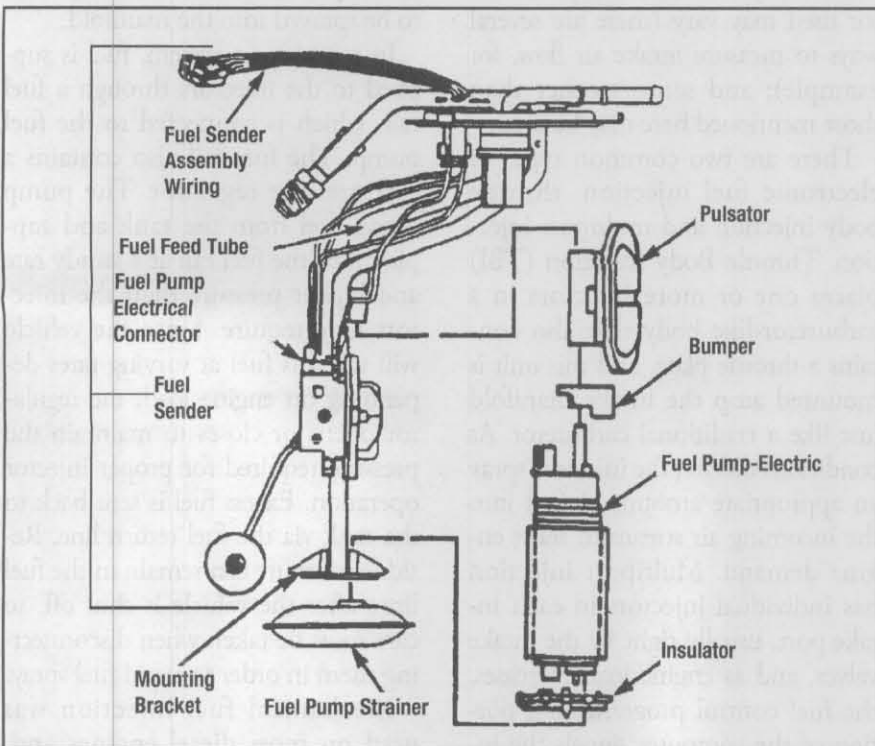
efficiency. Through the use of electronic controls and other methods of varying injection timing, much greater efficiency has been achieved. The most common method involves

using engine oil to activate an intensifier piston in the injector, which in turn injects fuel into the combustion chamber. The oil supply to these intensifier pistons is controlled via electronic solenoids that take cues from various sensors and process them through an ECM.

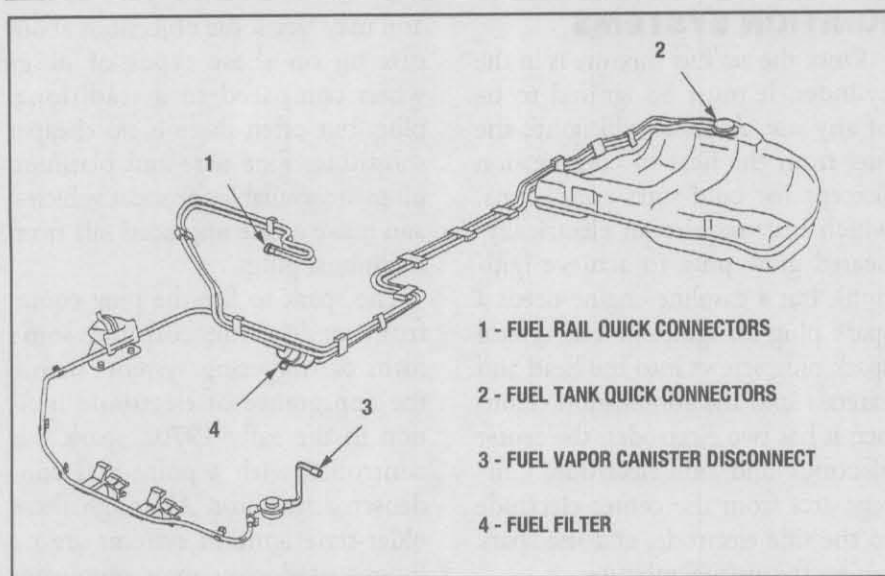
Dirt in the fuel can block carburetor and fuel injection passages, and cause wear due to the abrasive action of the dirt particles. Fuel filters are therefore a part of every fuel system. They will, however, vary in size and shape; some are mounted under the hood with the engine, while others are placed near the fuel tank. Fuel filter service is critical for both injector and fuel pump life. An inefficient filter can allow dirt into the injectors, causing poor operation, and a clogged filter can not only stop fuel delivery, but also destroy the pump.

Fuel must first be moved from the fuel tank to the engine compartment before being introduced into the engine. This is accomplished by means of a fuel pump, which can be either mechanical or electrically operated. Mechanical pumps are usually mounted on the side of the engine and have an internal diaphragm, actuated by a lever that rides on an eccentric on the camshaft, which creates a vacuum to draw fuel from the tank. These pumps only develop about 4 or 5 pounds of pressure and are only used on carbureted engines or as a boost pump to prime a diesel injection pump. When a mechanical pump fails it is almost always due to a bad diaphragm in the pump. This usually leads to fuel either being leaked to the outside via a weep hole in the casting or into the engine where it dilutes engine oil.

Electric fuel pumps are typical of electronic fuel injection systems and are often fuel tank-mounted. They are designed to provide much higher pressure, as much as 80 psi in some applications. You may also find vehicles with both an internally mounted



Typical in-tank electric fuel pump and fuel gauge sending unit assembly.



Typical fuel line routing. (Courtesy: GM Corp.)

charge pump in the tank and an externally mounted high-pressure pump. Some carbureted sports cars and high fuel volume applications use electric fuel pumps as original or aftermarket equipment. Electronic pump failure can be due to contaminated fuel, or improper voltage/connections at the pump. It's not unusual to have customers complain of new faulty pumps when in fact the problem lies either with the connections or the fuel pressure regulator. In any case you should be wary of customers who regularly complain of poor quality pumps or repeated failures of pumps on the same vehicle.

Fuel lines carry fuel from the fuel tank to the carburetor or fuel injection system. They are usually made from plated steel or copper, frequently with connections made of flexible hose. Only hose specifically designed for fuel should be used for this purpose, as gasoline can attack certain types of rubber and cause leaks. Between the fuel tank and mechanical fuel pump, fuel system hose must be heavy enough to prevent collapse from suction from the pump. Since electronic fuel injection systems operate at much higher pressures than carbureted systems, special hose and hose clamps are re-

quired. In areas of the country where road salt is used it is not unusual for steel fuel lines to rust out and start to leak. In engines with a mechanical pump, fuel is drawn from the tank by vacuum so if the line breaks it will only stop the vehicle and no fuel will be lost. However, fuel injected engines with in-tank mounted pumps may continue to run, allowing pressurized fuel to leak from the line and create a serious fire and explosion hazard. For this reason it is important that you sell the customer the correct type of lines, hose, and hose clamps whenever work is being performed on the fuel system.

Before fuel injection and electronic ignition, most service work on fuel systems consisted of air and fuel filter changes when a regular tune-up was performed. Carburetor service other than minor adjustments required a rebuild kit containing gaskets, a float valve, accelerator pump, and possibly a float also. Usually the only way to properly identify a rebuild kit for a carburetor is by the carburetor number itself. Application listings may not always be correct, due to the age of most carbureted vehicles and the ease with which carburetors can be changed. When selling fuel system items such as a carburetor rebuild

kit, fuel pump, etc., remember to recommend a new fuel and air filter as well as carb cleaner. Remind the customer to verify that the kit is correct for the application before opening or installing, as carburetor kits are sold in sealed containers and are usually not acceptable for return if the seal is broken.

Fuel injection systems won't require a major overhaul or frequent adjustments like a carburetor but they will benefit from regular preventive maintenance. Extended service intervals on ignition and other vehicle components may mean that fuel and air filters do not get inspected and changed as often as needed. Customers complaining of a lack of power or poor fuel economy should be reminded to check the basics before looking for more serious trouble. Regular use of a fuel injector cleaner and air intake spray cleaners can also help keep your customer's vehicle running smooth, clean and efficiently between service intervals. Electric fuel pumps are probably the most commonly replaced item in an injected system. Since they are usually mounted in the tank, it can require several hours of labor to remove and install a new one, so care must be taken when looking up and selling a replacement. Most in-tank electric pump manufacturers require that the filter and strainer be changed and the tank flushed in order to maintain the warranty. The most common reason for new pump failure is contamination due to sediment being disturbed when the tank was removed but not flushed out.

When looking up fuel system parts for some vehicles you may encounter references to alternative fuels such as propane, bio-diesel and ethanol alcohol. These are being offered in an effort to reduce both oil consumption and vehicle emissions. Some companies are also offering multi-fuel conversions that allow the vehicle to be run on both gasoline and propane

or compressed natural gas. Vehicles fueled solely on propane are more likely to be used by fleets or municipalities that don't have to travel too far from a central refueling point, or are the small industrial type that operate indoors. The conversion consists of a high pressure storage tank, a pressure regulator, and a special carburetor for use with the gaseous fuel.

Ethanol fuel is a mixture of gasoline and alcohol derived from corn, most often in a ratio of 15% gas to 85% alcohol, and is referred to as E85 or flex fuel. A sensor in the fuel line or tank detects the presence of alcohol and tells the ECM to alter the operating parameters to compensate for the difference in fuels. Vehicles set up to operate on flex fuels can also run on conventional gasoline but not the other way around. Alcohol does not burn at the same temperature or rate as gasoline, so changes to the ignition timing and injection rates must be made to compensate for this. There may also be an issue with hoses and rubber components being melted or distorted by the alcohol, especially in older vehicles.

Bio-diesel is fuel consisting of a blend of regular diesel and fuel derived from soybeans, or 100% soy fuel. Blends are labeled as Bxx with the xx representing the percentage of bio fuel in the blend. Most diesel vehicles can run on a blend of bio fuel but there may be issues with component compatibility and filter clogging in higher concentrations. Another issue to remember is the government mandated switch to ultra low sulfur diesel fuels, which started in 2006. While this should not cause problems with older vehicles not designed to use it, you may find some customers that will insist on using a fuel supplement to add lubricity to the fuel that the higher concentrations of sulfur provided in the older fuels.

IGNITION SYSTEMS

Once the air/fuel mixture is in the cylinder, it must be ignited to be of any use. A diesel will ignite the fuel from the heat of compression (except for cold-start conditions, which may require an electrically-heated glow plug to achieve ignition), but a gasoline engine needs a spark plug for ignition. The typical spark plug screws into the head and extends into the combustion chamber; it has two electrodes: the center electrode and side electrode. Current arcs from the center electrode to the side electrode, and the spark ignites the air/fuel mixture.

All spark plugs are not the same, however. They differ in physical size and in heat range, which is the amount of heat the spark plug retains and how much is passed on to the head. Stated another way, it is a measure of how quickly the spark plug passes heat to the head; the hotter the plug the slower heat is transferred. A spark plug that is too hot for the application can cause preignition (early firing), which leads to detonation and can destroy an engine. A spark plug that is too cold can collect deposits, or foul, which can short out the plug and cause the engine to misfire. A misfiring engine can supply the catalytic converter with an overly rich mixture and cause it to overheat, which would damage the converter and may also ruin oxygen sensors.

More and more vehicle manufacturers have been recommending 100,000-mile plug change intervals, both as a convenience to the motorist and due to limited accessibility of the plugs. This has become possible through the use of plugs with special platinum or gold-plated fine wire electrode tips. However, this does not mean that all vehicles will achieve this mileage on a set of plugs. If the rest of the ignition and fuel injection system is not kept in good order, it will affect plug life.

You may face some objections about pricing on these types of plugs when compared to a traditional plug, but often there is no cheaper substitute. Fine wire and platinum plugs are available for most vehicles, and make a nice upgraded sale from traditional plugs.

The spark to fire the plug comes from an ignition coil and some form of triggering system. Before the appearance of electronic ignition in the early 1970s, spark was controlled with a point-and-condenser distributor. Although these older-style ignition systems are no longer used, you may encounter parts requests for some of the older vehicles still on the road or for industrial equipment. The following is a basic description of these older systems.

The ignition coil is actually two sets of windings, a primary winding of heavier wire around a secondary winding of fine wire. Technically, the coil is a pulse-type transformer that raises the battery's voltage of 12 volts to as high as 20,000-40,000 volts. This is accomplished by running battery voltage through the primary winding and creating a magnetic field. The field is collapsed when the points open, which causes current to flow through the secondary windings. This current is multiplied by the number of secondary windings in the coil and flows through the coil wire to the distributor and then on to the spark plugs.

The electrical circuit to the primary winding in the coil is made and interrupted by the breaker points, more commonly called points. Points are electrical contacts (made of tungsten steel) located on a lever with a rubbing block, which rides on a distributor cam in the distributor. As the lobes on the distributor cam push against the rubbing block, the points make and break contact, making and breaking

Design Symbols: Spark Plugs

Thread Diameter	
A:	18 mm
B:	14 mm
C:	10 mm
D:	12 mm
J:	12 mm

E:	19 mm (3/4")
EF:	Tapered Seat 17.5 mm (.708" Reach)
FS:	Tapered Seat 10.9 mm (.460")
H:	12.7 mm (1/2")
EH:	Partial thread 19 mm (3/4" Total Reach) 12.7 mm (1/2" Total Thread)
L:	11.2 mm (7/16")
S:	9.5 mm (3/8") Reach
Z:	21 mm
NO SYMBOL:	
18mm = 12 mm Reach	
14mm = 9.5 mm (3/8") Reach	

Construction (ONE OR MORE LETTERS MAY BE COMBINED)	
C:	Hex Size 5/8"
K:	Hex Size 5/8" Projected Tip (ISO)
M:	Compact Type
P:	Projected Insulator Type
R:	Resistor Type
U:	Surface or Semi- Surface Discharge Type
Z:	Inductive Resistor

Firing End Construction

A:	Special Design	M:	2-Ground electrodes For Mazda Rotary Eng.
B:	Special Design	N:	Special Side electrode
C:	Low Angle Ground Electrode	P:	Premium Platinum
CM:	Compact type, low angle ground electrode	Q:	4-Ground electrode
E:	V-Grooved center electrode (14mm only) 1.5mm Insulator	R:	Special Ground electrode
ES:	Standard 3/4" Thread Reach (2.5mm) center electrode	S:	Standard 2.5mm center electrode
F:	Tapered Seat	T:	3-Ground electrode
G:	Fine wire nickel alloy center electrode	U:	Semi-surface discharge
G-G:	Copper core ground electrode	V:	Fine wire gold palladium center electrode
GP:	Platinum Firewire (6mm)	VX:	High performance platinum
GV:	Gold-palladium center electrode Special Construction of V-Type. Racing use	W:	Tungsten electrode
IX:	High Performance Iridium	X:	Booster gap V-Grooved center electrode (14mm only) 2.5mm Insulator
K:	2-Ground electrodes	Y:	Thick 2.9mm center electrode
L:	Half heat range, (See spec. chart)	Z:	
LM:	Compact type for Lawn Mower		

B C P R 6 E S - 11

Plug Type	
I:	Iridium Platinum
L:	Thread Reach 26.5mm
P:	Premium Platinum
Z:	Extended Gap

Heat Rating Numbers	
2 Hot	↑ ↓
11 Cold	

Firing End Construction	
A, B, C...: Special Design	

- WIDE GAP -	
8	0.8mm (.032")
9	0.9mm (.036")
10	1.0mm (.040")
11	1.1mm (.044")
13	1.3mm (.052")
14	1.4mm (.055")
15	1.5mm (.060")
20	2.0mm (.080")

P F R 6 A - 11

Metal Shell Size	
F:	ø 14, 19mm (3/4") Reach, 16mm (5/8") Hex.
G:	ø 14, 19mm (3/4") Reach, 20.6mm (13/16") Hex.
J:	ø 12, 19mm (3/4") Reach, 19mm Hex.
M:	ø 10, 19mm (3/4") Reach, 16mm (5/8") Hex.
T:	Tapered Seat ø 14, 17.5mm Reach, 16mm (5/8") Hex.
PTR5A-13:	ø 14, 25mm Reach, 16mm (5/8") Hex.

Construction	
R: Resistor	

The part number of a typical spark plug carries almost as much information about the part as a vehicle identification number carries about the vehicle. (Courtesy: NGK Spark Plugs)

the primary coil windings circuit. Although technically the points are the contacts, in common usage the term 'points' refers to the whole breaker arm assembly, which is how it is sold. A condenser is a roll of foil and insulation; its purpose is to absorb the continuous flow of current from the battery so that it will not arc across the contact points when they are opened. Even with a condenser however, points will eventually pit and burn due to the constant arc across them and the only fix is to replace them or attempt to file them smooth again with an ignition file or stone. Condensers are usually changed along with points during a traditional tune-up.

The high-voltage current coming from the coil is directed to the proper spark plug by the distributor. A rotor fits on top of the distributor shaft, which is turning at one-half crankshaft speed, and through a conductive strip, it directs the current from the center or coil terminal in the distributor cap to the side or spark plug terminals. The current then travels to the spark plug via a plug wire. With the traditional ignition system, a tune-up included setting the point gap or dwell using feeler gauges or a dwell meter, and setting spark timing with a timing light. It also meant replacing the spark plugs, points and condenser, as well as checking the coil and plug wires, the rotor and distributor cap, and replacing any parts that were worn out.

Almost all vehicles manufactured since the 1970s have electronic ignition systems. On distributor-type electronic ignition systems, dwell is controlled automatically by an ignition control module and is not adjustable. A magnetic pickup assembly replaces the points and the spark is triggered by a trigger wheel placed where the breaker cam used to ride. As the vanes of the trigger

wheel pass the stationary pickup, a signal is sent to the control module, which makes and breaks the primary coil circuit causing the system to produce a spark at the coil. The pickup coil and trigger wheel do not have a replacement interval and need to be replaced only if they fail or are damaged.

Electronic ignition systems produce a more powerful spark than traditional breaker points systems and can better tolerate degraded components, such as distributor caps and wires, before misfiring occurs. This is not always an ideal situation however, because the added resistance produced by a poor wire set or cap and rotor can cause premature failure of expensive components, such as spark control modules or coils. Caps, rotors, and wires should still be checked and replaced as a part of regular maintenance since they are subject to oxidation from long usage and degradation due to underhood temperatures and chemical contamination.

All vehicles with breaker points and some with electronic distributors used a vacuum advance unit on the side of the distributor to adjust ignition timing in relation to engine load. As the throttle is opened manifold vacuum decreases, causing the advance unit to move the base plate with the points or magnetic pickup attached in relation to the breaker cam or trigger wheel. Moving the plate in the opposite direction of distributor rotation would cause the spark to occur at a point before where the original, or base line timing, was set, giving the greater fuel charge from the opened throttle more time to burn.

Most vehicle manufacturers are now using systems that do away with the distributor altogether. Sensors are used to provide information on crankshaft position, engine speed, engine load, coolant temperature, and vehicle speed to the

ECM and control module. The module and ECM then adjust ignition timing as needed and fire each plug through a coil pack. The coil pack has half as many coils as the engine has cylinders and fires two plugs at the same time. Since a 4-stroke engine with an even number of cylinders has two pistons near top dead center at the same time—one on compression and one on exhaust — a single coil can be used to fire both plugs. The cylinder on the exhaust stroke does not utilize the spark and it is called a waste spark. Some systems have no plug wires at all and the primary wiring leads to coils mounted on each spark plug. These are known as Coil-On-Plug or 'COP' systems.

A control module or logic module is the computer that controls the spark timing. (Fuel injection and other electronic controls may also be located in the same unit.) The control module is usually protected from heat, so it may be located within the passenger compartment or in a relatively cool location under the hood. Chrysler, for example, cools the electronics on some models by putting the control module in the engine intake tract — away from the engine. Ford went from a fender mounted unit about four inches square to a small distributor mounted one that requires a heat sink compound to protect it. Control modules will generally not give any indication that anything is wrong until they fail and the vehicle stops running. In some cases the vehicle may start again after the module cools down, but it will fail as soon as it heats up, so replacement is the only solution.

Due to the complexity of some ignition systems the DIY customer, and even some professional installers, may not fully understand or have the tools to diagnose an ignition problem. All electronic components under the hood of a modern

automobile must be able to withstand extreme levels of temperature and vibration and it's often impossible to tell a defective part from a serviceable one without using proper diagnostic tools and procedures. This can lead to random replacement of parts that are not really needed. Often a part that fails to fix the car will be returned as defective when in fact it is not, or if it is bad it may have been caused by another condition on the vehicle. This is especially true of ignition or control modules. If you have a customer who has a repeated failure of the same component, chances are that the problem lies elsewhere. Many stores have a no return policy on electrical items that allow for replacement of a defective part only, but not a refund. This is to keep people from buying an item for test purposes only and returning it if it does not fix the problem. Keep this in mind when you have a cus-

tomor who just can't seem to find the cause of his trouble.

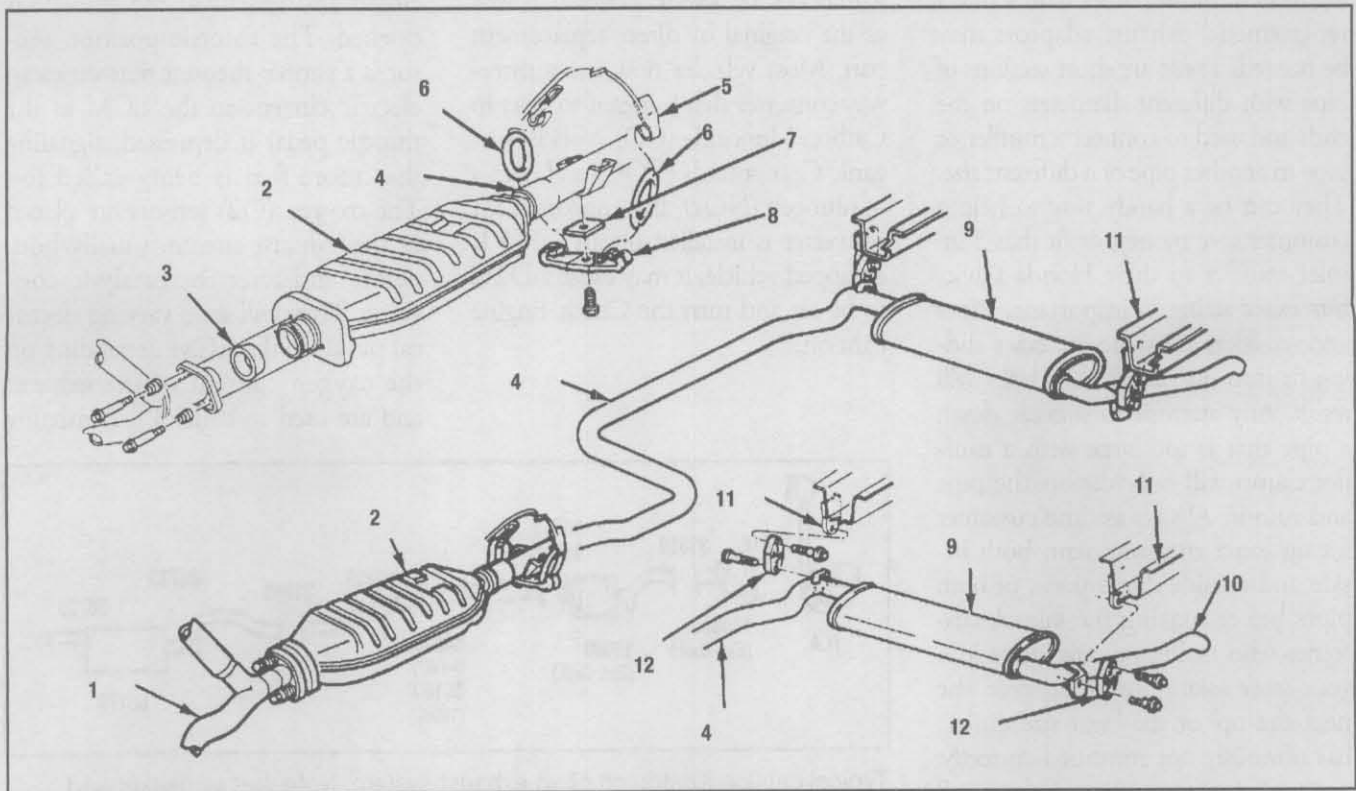
EXHAUST SYSTEMS

After the air/fuel mixture is burned, it must be removed from the cylinder so that the next cycle can take place. The burnt gases, or exhaust, are pushed out of the cylinder by the piston rising on the exhaust stroke, past the exhaust valve and through the exhaust port in the head. From there the exhaust goes to the exhaust manifold, typically made of cast iron, which gathers the exhaust into (usually) a single tube. The exhaust pipe is attached to this front single tube. On most vehicles since 1975, there are one or more catalytic converters, which remove exhaust pollutants (more information on the types and operation of these is found in the emissions section). To reduce engine exhaust noise, there is at least one muffler in the exhaust system, and possibly a second, smaller muffler

called a resonator. The last section of exhaust pipe is commonly referred to as the tailpipe, though some people use that term for the entire system.

The number one cause of exhaust system failure is rust out. The gases and chemicals that pass through the exhaust can be very corrosive, and when mixed with water condensation can lead to early rusting of exhaust pipes and mufflers. Vehicles that are only used on short trips, where the exhaust never reaches optimum operating temperature, are especially prone to this.

Some vehicles are equipped with dual exhaust systems for better performance and/or different exhaust tone. A dual exhaust is, in essence, two exhaust systems. They may share a single catalytic converter, or have two in parallel. A crossover pipe, a pipe connecting the dual exhaust pipes not far from the engine, is often used on dual exhaust systems to help quiet exhaust noise and balance exhaust flow.



Exhaust system components: 1-Exhaust Manifold Rear Pipe; 2-Catalytic Converter; 3-Seal; 4-Intermediate Pipe; 5-Body Bracket; 6-Hanger (O-ring type); 7-Insulator; 8-Bracket; 9-Muffler; 10-Tailpipe; 11-Underbody; 12-Hanger. (Courtesy: GM Corp.)

Exhaust system sales offer a few good opportunities for upgraded and add on sales. At the very least, you should provide new clamps whenever any portion of the exhaust is replaced, as well as any required gaskets and hangers. It's possible for a new exhaust system to be destroyed due to the old hangers being reused and breaking, causing the exhaust to drag on the ground. Many new vehicles have exhaust systems that are welded together into one piece from the catalytic converter on back, or they are made from stainless steel, which has better corrosion resistance than regular steel. When one component fails or becomes damaged, everything must be replaced at once even though the pipes and muffler may be available separately. There are also a number of performance mufflers and stainless steel systems available through the aftermarket for the customer who wants to personalize their vehicle.

In the case of a customer who is trying to fit a muffler other than a direct replacement, exhaust adaptors may be needed. These are short sections of pipe with different diameters on the ends and used to connect a muffler or pipe to another pipe of a different size. They can be a handy way to help a customer save money, or fit that 3-in. inlet muffler to their Honda Civic, but exact sizing is important. Pipes and mufflers must be an exact sliding fit into one another or leaks will result. Any attempt to squeeze down a pipe that is too large with a muffler clamp will only distort the pipe and ruin it. Always ask the customer for an exact measurement, both inside and outside dimensions, of both pipes before making the sale. A customer who makes repeated trips into your store asking for an adaptor 'the next size up' or the 'next size down', has obviously not measured correctly, and with every incorrect pipe you sell them the risk of them trying to force it and ruin it goes up. It should also be noted that pipes from different af-

termarket manufacturers might not always be interchangeable. A customer that buys a muffler from you but has to get the tailpipe from your competitor may run into fit problems where an adaptor may be necessary.

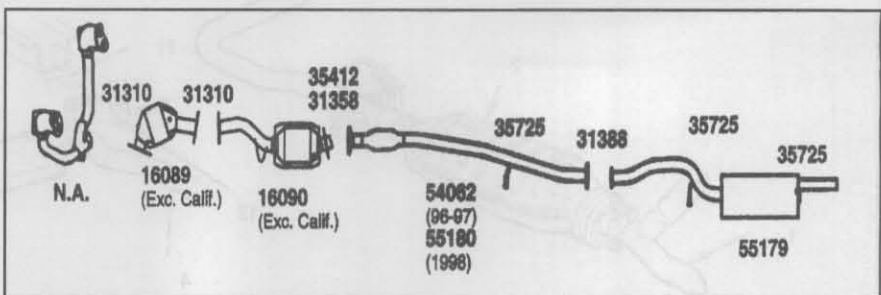
Some aftermarket manufacturers are offering mufflers that are warranted for as long as the original purchaser owns the vehicle. If you are selling one of these mufflers make certain that the customer is aware of any registration or documentation that may be required before a replacement can be given. In most cases these warranties only cover the muffler itself and not any of the other pipes in the system, so this should also be mentioned. The same stipulation also applies to replacement catalytic converters.

Another consideration with a replacement catalytic converter is making sure that it will function properly in the vehicle into which it is being installed. A universal replacement converter may physically fit a vehicle but it may not be able to perform as well as the original or direct replacement part. Most vehicles now use a three-way converter that is meant to react to Carbon Monoxide (CO), Volatile Organic Compounds (VOC) and oxides of nitrogen (NOx). If a noncompliant converter is installed on an OBD II equipped vehicle, it may cause a DTC to be set and turn the Check Engine light on.

ENGINE MANAGEMENT AND EMISSIONS CONTROL SYSTEMS

All vehicles presently manufactured have some form of engine management system, which controls both ignition and fuel injection, as well as some aspects of power delivery. Engines controlled in such a manner are far more efficient and produce far less pollutants than older carbureted and breaker point-ignition vehicles. These systems have various sensors that indicate things such as crank and camshaft position, manifold pressure, vehicle speed, engine temperature, throttle position, and oxygen content of exhaust gases, as well as other information.

Crank and cam position sensors are used to control ignition timing in distributorless ignitions. A Manifold Absolute Pressure (MAP) sensor is used to determine engine load; high manifold vacuum occurs when the throttle butterfly valve is closed and lessens as the throttle is opened. The throttle position sensor is a simple rheostat that varies an electric current to the ECM as the throttle pedal is depressed, signaling that more fuel is being called for. The oxygen (O2) sensors are placed in the exhaust stream, usually both before and after the catalytic converter. They will send varying electrical pulses to the ECM depending on the oxygen content of the exhaust and are used to control fuel mixture



Typical catalog illustration of an exhaust system. Note that all gasket and hanger numbers are listed but the smaller start up converters that are part of the Y-pipe have an NA next to them signifying they are not available. Also note that the other two converters are for 49-state use only and not for California. (Courtesy: Tenneco Corp.)

and relay information on catalytic converter efficiency.

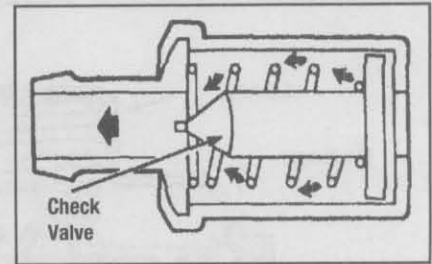
The information gathered by the sensors is sent to an ECM or PCM (Powertrain Control Module), depending on function. The control module processes the information and compares it to parameters pre-programmed at the factory. It then makes adjustments in settings such as ignition timing, fuel injection, air pump operation, and EGR (Exhaust Gas Recirculation), as well as gear selection on some models. The ECM/PCM is programmed to operate in two modes, open loop and closed loop. In open loop mode, which under normal conditions is only when the engine is cold, ignition, injection, and EGR/AIR functions may operate at a predetermined setting regardless of signals being sent by the O₂ sensors. As the engine warms and enters closed loop mode, the various emission control systems will come into play and fuel mixture will be controlled for optimum efficiency and lowest emissions.

ECM/PCM units are, as a rule, very reliable and failure is often due to outside influences such as an accident, corrosion of the contacts, or a voltage spike. All ECM/PCM units have an identification number attached to them and no substitutions should be made unless the manufacturer states it will work in that application. Also, if a unit fails, the cause of the failure should be determined before the replacement is installed. The voltage supplied to these units is usually much lower than battery voltage, so this should be checked. All wiring and solenoids controlled by the ECM/PCM should also be checked for shorts and low resistance. Finally, never touch the connecting pins or solder components on an ECM/PCM. As mentioned above, the voltage they operate on is very low, and as little as 100 volts of static electricity off your fingers can damage them. By comparison, it

takes almost 4000 volts for the average person to feel the zap of a static discharge.

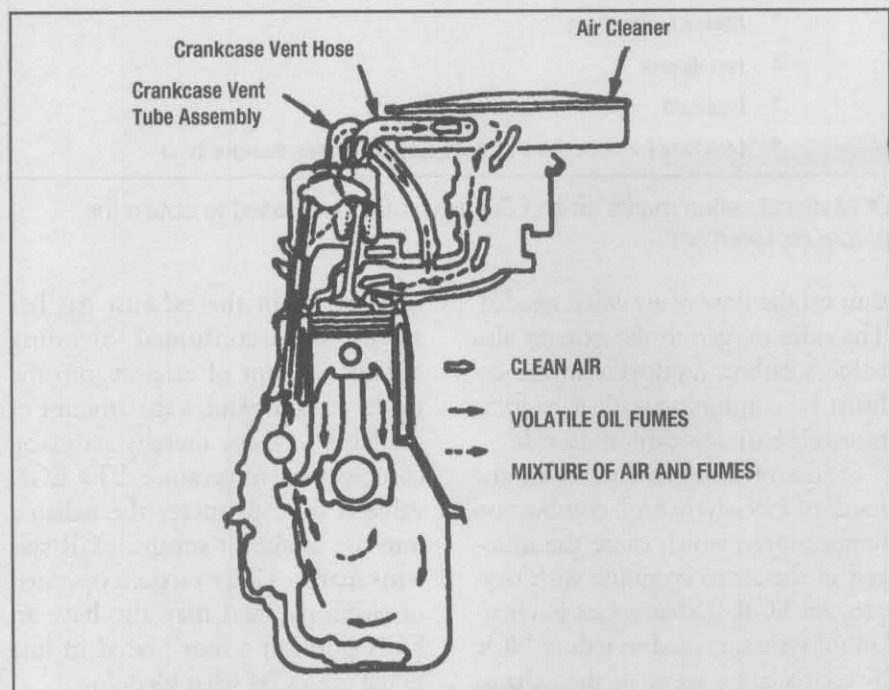
The automobile has been identified as a significant contributor to the problem of air pollution, the primary harmful emissions being unburned hydrocarbons, oxides of nitrogen and carbon monoxide. Automobile hydrocarbon emissions can come from the exhaust, the crankcase ventilation system, carburetor leakage and gas tank fumes.

The problem of emissions from crankcase ventilation systems was solved with the installation of PCV (Positive Crankcase Ventilation) systems. The engine crankcase must be ventilated to allow the removal of fumes from blowby and oil evaporation. The PCV system ducts these fumes into the intake manifold, where they are drawn into the cylinder and burned. A PCV valve meters the flow so it does not upset the air/fuel mixture from the carburetor or fuel injection and protects the crankcase from any backfire into the intake manifold. The PCV valve must be checked periodically and replaced when it becomes clogged or sticky.

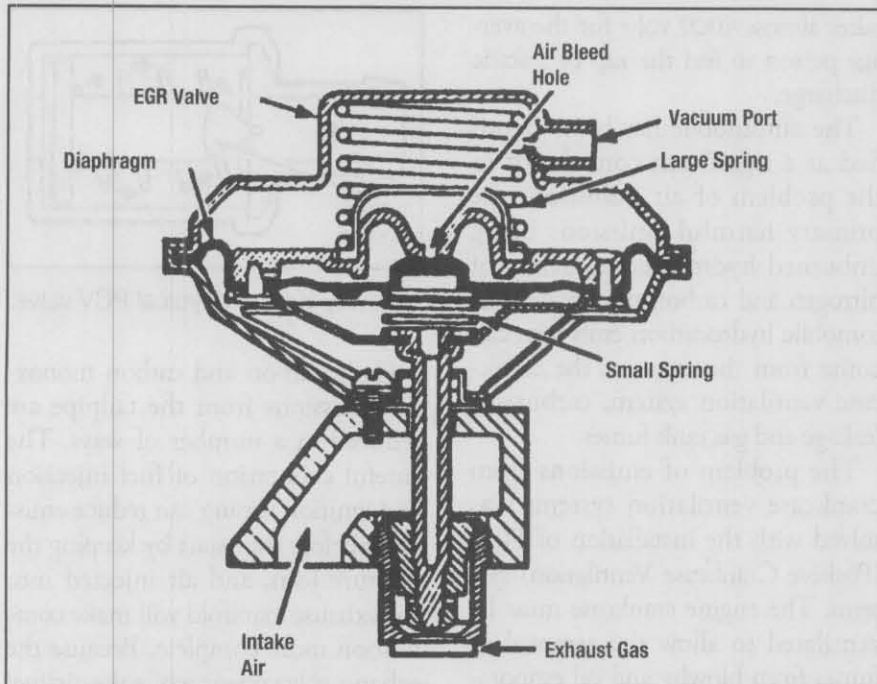


Cutaway view of a typical PCV valve.

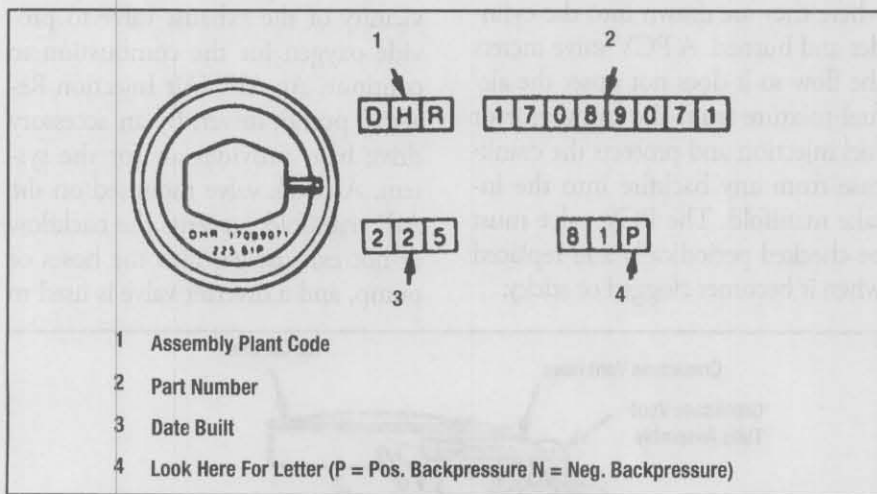
Hydrocarbon and carbon monoxide emissions from the tailpipe are reduced in a number of ways. The careful calibration of fuel injection and ignition timing can reduce emissions before they start by keeping the mixture lean, and air injected into the exhaust manifold will make combustion more complete. Because the exhaust valve opens while the air/fuel mixture is still burning, air is admitted into the exhaust manifold in the vicinity of the exhaust valve to provide oxygen for the combustion to continue. An AIR (Air Injection Reactor) pump, driven by an accessory drive belt, provides air for the system. A check valve mounted on the AIR manifold prevents the backflow of hot exhaust gas into the hoses or pump, and a diverter valve is used to



Schematic of a typical PCV system.



Cutaway view of a typical EGR valve.



OEM identification marks on an EGR valve may be needed to obtain the proper replacement.

shut off the flow of air when needed. The extra oxygen in the exhaust also reduces carbon monoxide in the exhaust by combining with it to form relatively harmless carbon dioxide.

Oxides of nitrogen (NO_x) are the result of excessively high combustion temperatures, which cause the nitrogen in the air to combine with oxygen. An EGR (Exhaust Gas Recirculation) system is used to reduce NO_x by recirculating some of the exhaust gas into the intake manifold. Because

the oxygen in the exhaust gas has already been consumed, blending a slight amount of exhaust into the intake stream reduces the amount of available oxygen, thereby reducing combustion temperature. The EGR valve is used to meter the exhaust into the intake air stream. EGR systems may be either vacuum operated or electronic, and may also have an EGR position sensor placed in line to tell the ECM what it's doing.

EGR function must be controlled

because there are times, such as when the engine is cold, when EGR is not required. Until the engine is warm, there is no need for EGR because combustion is still sufficiently cool. On early non-ECM/PCM engines the EGR was controlled by a thermo-switch inserted into the coolant passages or thermostat housing. As the engine warmed up the hot coolant caused the switch to open and allow vacuum to open the EGR. On electronically controlled vehicles, a coolant temperature sensor installed in the same place as the old thermo-switch tells the ECM when the engine has reached operating temperature. The ECM then signals an EGR solenoid to open and allow vacuum or electric current to open the EGR valve.

Catalytic converters are perhaps the most well known emission control devices. Located in the exhaust system, a catalytic converter resembles a muffler but contains special metal alloys, which function as catalysts (basically, agents of chemical change which themselves do not change). The converter transforms smog-creating exhaust emissions into relatively harmless gases but it must operate at very high temperatures to do so. On a cold start the converter may take some time to warm up to operating temperature, so some vehicles may be equipped with a small start-up converter mounted at the exhaust manifold, which heats up quickly during cold engine start-up.

Catalytic converters and O₂ sensors can be ruined by the use of gasoline containing lead or by excessive engine oil or antifreeze leaking into the combustion chamber, or by an excessively rich fuel mixture.

Due to the warranty required on emissions systems when they were first introduced, many items were not readily available in the aftermarket, and as a result, many catalytic converters were removed or drained, and AIR pumps were disconnected.

This is no longer an option, however. Laws have since been passed making it illegal to disable or bypass emission controls, and most states now require emission testing as part of the annual safety inspection. Also, even if it was legal to do so, with the ECM/PCM controls on modern vehicles, poor performance would result at best, and possible severe engine damage at worst if emission components were removed or disabled. Some manufacturers even recommend replacement of the O₂ sensor as part of regular maintenance schedule to keep the rest of the system operating at peak efficiency.

In order to make troubleshooting easier, ECM/PCM controlled vehicles have a diagnostic feature that can be accessed with the proper scan tool, to help the technician or DIY customer pinpoint problems. When a component or system malfunctions, the ECM records it as a trouble code and turns on the Malfunction Indicator Light (MIL) or Check Engine light. When the codes are retrieved it will point the customer in the right direction but it is not the final word. The customer who replaces an EGR valve because the ECM set that code will be disappointed when a new valve doesn't cure their problem because the vacuum line to the valve was cracked. Be sure to remind your customers that the various sensors and solenoids are part of a complex system and that every aspect of it needs to be in top condition for it all to work properly.

Proper testing of sensors and senders requires the use of a Digital Multimeter (DMM). Input and signal current is measured in milliamps and very low voltages. A digital, not analog (needle type) meter must be used in order to accurately and properly diagnose a component. Since sensors are electrical, returns are usually limited to warranty replacement to discourage people from replacing

parts until they find the one that fixes the problem, and returning the rest. Also, certain types of silicone sealants can destroy oxygen sensors if they are used on the intake manifold or other applications where the fumes can enter the exhaust stream.

Another source of harmful emissions comes not from the vehicles exhaust, but from the fuel before it is burned. As temperature and conditions change in the fuel tank small amounts of the fuel can vaporize, causing pressure to build within the tank. Systems have now been mandated and put in place to capture and burn fuel vapors rather than vent them to the outside, as was done in the past. As pressure builds in the tank from fuel evaporation, a valve allows it to vent into a canister filled with charcoal, where it is stored until the ECM tells it to purge. The ECM will then open a canister purge valve, which allows the fuel vapors to be directed into the intake system and burned. The main components of the EVAP system are the tank vent valve, the canister, and the purge valve, along with any solenoids and tubing used to activate them, and a sensor to detect pressure within the system. Trouble can occur when any of the components are damaged due to accident or exposure to the elements and road salt, resulting in the check engine light illuminating and a trouble code to be set. A faulty gas cap, or even refueling with the vehicle running can cause the ECM to set an EVAP code, and they can be very difficult to diagnose without the proper test equipment. If a simple physical inspection of the components doesn't turn up anything obvious, smoke generating units can be used to fill the system making it easier to spot any leaks that may have occurred in hoses, tubing or other parts of the system. In addition, less expensive code scanners, or those not supported with OEM data, may only

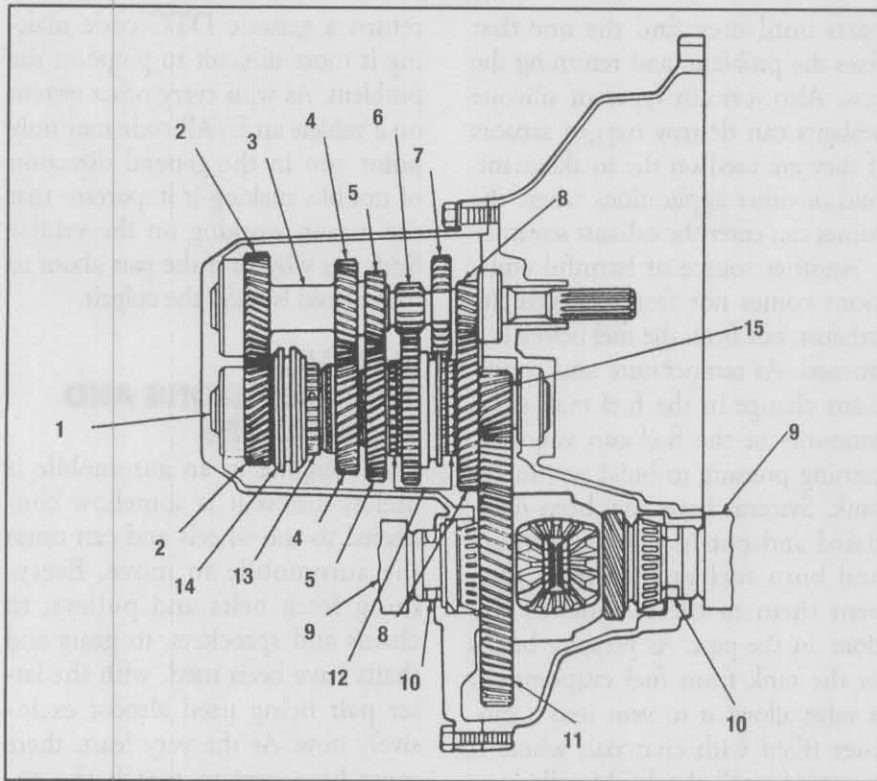
return a generic DTC code making it more difficult to pinpoint the problem. As with every other system on a vehicle an EVAP code may only point you in the general direction of trouble, making it important that the person working on the vehicle finds out why, or if the part about to be replaced is really the culprit.

MANUAL TRANSMISSIONS AND TRANSAXLES

The engine in an automobile is useless unless it is somehow connected to the wheels and can cause the automobile to move. Everything from belts and pulleys, to chains and sprockets, to gears and shafts have been used, with the latter pair being used almost exclusively now. At the very least, there must be a way to match the engine's operating rpm to vehicle road speed. Gears do this, and also provide torque multiplication, increasing the twisting force. This is simply a matter of leverage: the larger the driving gear is in relation to the driven gear, the longer its lever arm effect on the smaller gear. Gears that are the same size (that is, direct drive) have no torque multiplication effect.

Even the earliest vehicle manufacturers saw a need for different gear ratios. However, this was largely because engines ran at only one speed, and therefore the different gear ratios gave the automobiles different running speeds. This is why we still call a transmission with three gear ratios a three-speed transmission.

The typical modern manual transmission has four shafts, along with bearings, gears, synchronizing devices and a shifting mechanism, all in a cast iron or aluminum housing. The shafts are the input shaft, output shaft, countershaft and reverse idler shaft. Between the input shaft and countershaft are



Manual transaxle components: 1-Mainshaft; 2-4th Speed Gears; 3-Input Cluster; 4-3rd Speed Gears; 5-2nd Speed Gears; 6-Reverse Gear; 7-Reverse Idler Gear; 8-1st Speed Gears; 9-Halfshafts; 10-Differential Oil Seals; 11-Final Drive Ring Gear; 12-1st/2nd Speed Synchronizer Blocker Rings; 13-3rd/4th Speed Synchronizer Hub; 14-3rd/4th Speed Synchronizer Sleeve; 15-Pinion Gear Part of Mainshaft.

two gears in constant mesh, continuously turning with each other. Along the countershaft are gears of various sizes; in a three-speed manual there are two gears. The output shaft is in a direct line with the input shaft and is splined — that is, it is grooved. In a non-synchronized transmission, the gears slide on the output shaft to match with the gears on the countershaft. The power is transmitted from the input shaft, through the gears to the countershaft (which rotates in the opposite direction), and back through the gears to the output shaft. For direct drive (usually 'high' in a three-speed transmission), the output shaft is locked to the splined end of the input shaft.

Modern manual transmissions are synchronized, which eliminates the need for the driver to precisely match gear speeds to road speeds.

The failure to do so results in grinding gears in a non-synchronized transmission. In the synchronized, or synchromesh, transmission, the gear on the output shaft is not splined onto the shaft. In fact, the gear remains in contact with the gear on the countershaft at all times, making this type of transmission sometimes called constant mesh. To make the connection that allows power to flow through the transmission, synchronizers are placed on the output shaft and slide on the shaft. The synchronizer has external splines that match the internal splines of the gear on the output shaft. So that these internal and external splines can be meshed, a spring-loaded clutch device is fixed to a splined slider on the output shaft, which makes the output shaft and countershaft — and hence the splines — turn at the

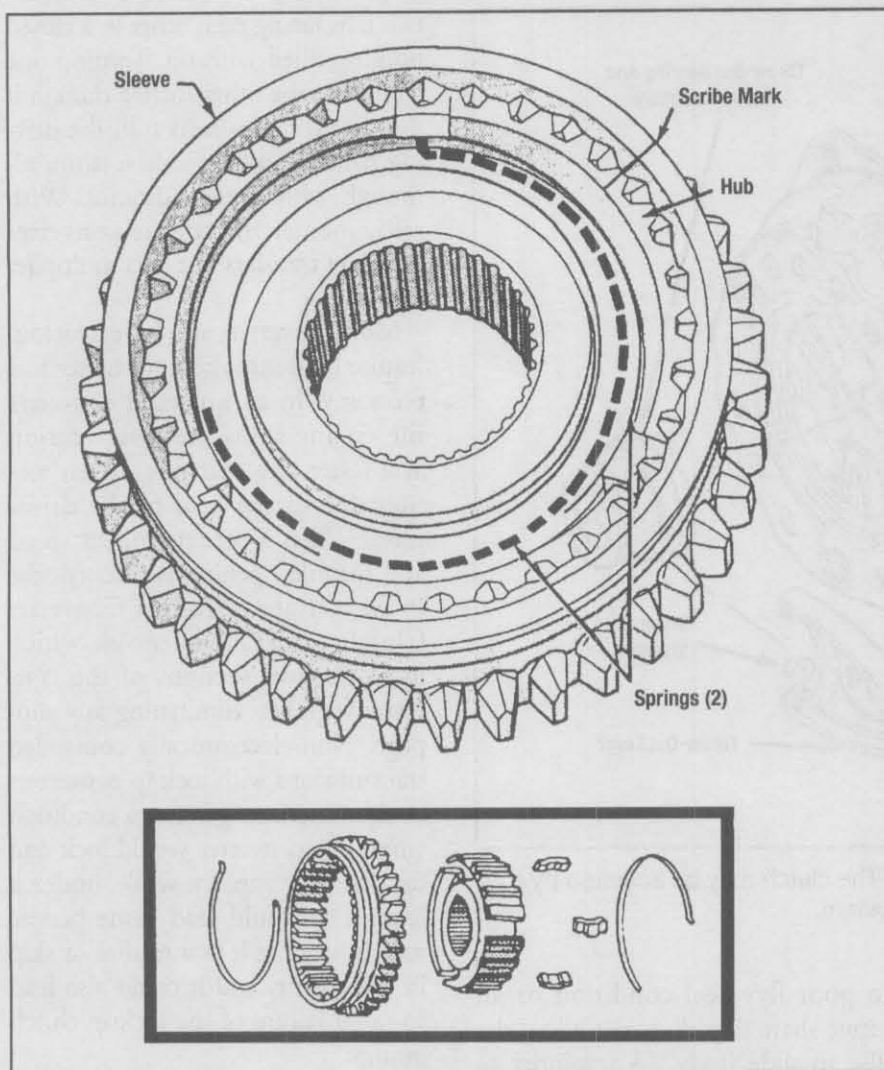
same speed. Forcing synchronizers to match very different shaft speeds will, however, cause premature wear of the synchronizer clutches.

For reverse, a third shaft in the rotation series causes the output shaft to turn in the opposite direction. Reverse is usually not synchronized, although it can be.

To slide the gears or synchronizers on their shafts, levers called shifter forks are used. A cam and shaft hold the transmission in the gear selected. Rods connecting the shift lever inside the vehicle to the levers on the side of the transmission case are collectively called the shift linkage.

A front engine, rear-wheel drive vehicle usually has the transmission bolted directly to the back of the engine, and a driveshaft takes power from the transmission to a differential and then to the rear wheels. The differential compensates for different wheel speeds when the car is turning a corner. Front-wheel drive vehicles, whether the engine is longitudinal (fore and aft) or transverse (crosswise), combine the transmission and differential in one unit called a transaxle. Transaxles are also used in mid-engine and rear-engine cars, and in some front engine, rear-wheel drive cars including the Porsche 924/944 and Subaru all wheel drive models.

Most transmission service consists of changing fluids and seal replacement unless major damage has occurred due to accident or abuse. The average aftermarket outlet is generally limited to supplying things like gaskets and seals. Parts such as gears, shafts, and synchronizer assemblies are usually OEM or specialty shop items. However, in situations where the transmission must be removed, there are things the average aftermarket store can help with. Related parts such as gear oils, universal joints or halfshafts and transmission mounts,



Assembled and disassembled views of a typical synchronizer assembly. Brass synchro rings are one of the highest-wear items in the entire transmission, due to the fact that a synchro ring is used every time the driver shifts the transmission.

may all be needed when the transmission is reinstalled, and synthetic oils can make a nice upgrade.

The flow of power from the engine though the drivetrain must sometimes be interrupted, such as when shifting a manual transmission's gears or to allow the engine to run with the vehicle stopped without putting the transmission in neutral. A clutch is used to allow this interruption. A clutch is a mechanism that can be engaged to complete the drivetrain or released to allow the engine to turn freely. The major components of the modern automotive clutch are

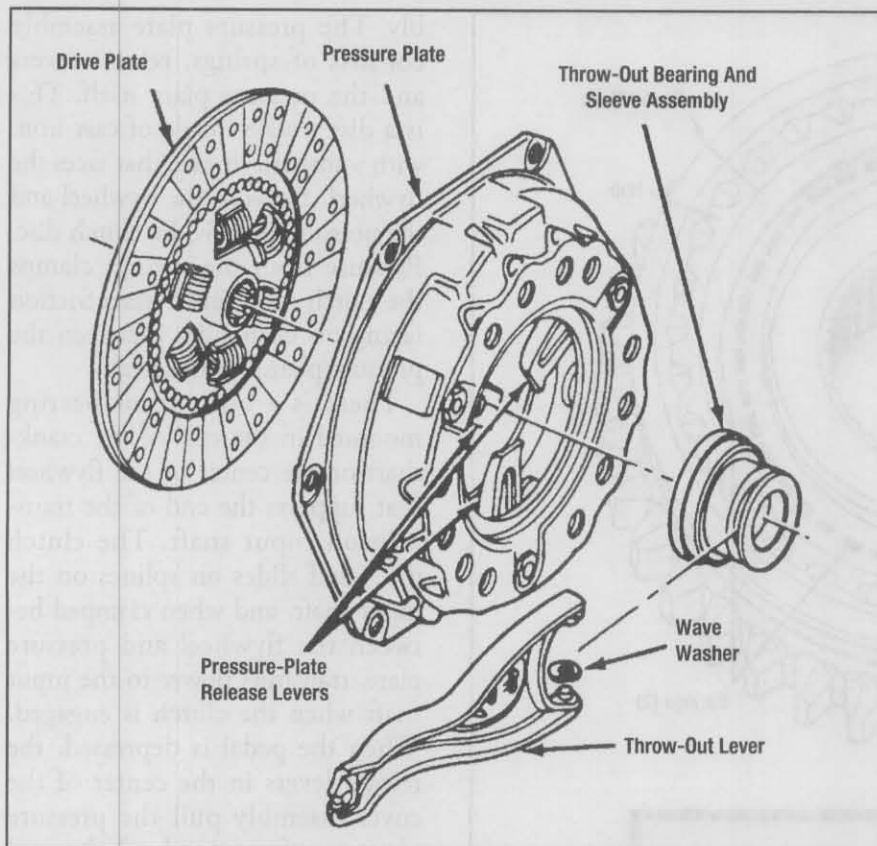
the flywheel, the clutch disc, the cover assembly, the release bearing, and the pilot bearing.

The flywheel is bolted to the transmission end of the crankshaft and its primary function is to smooth engine operation with its rotating mass. It also has a ring gear attached to its outer circumference that the starter motor drive engages to start the vehicle. The rear side of the flywheel disc has a smooth finish, which is called the flywheel clutch surface. Bolted to this backside near its outside edge is a bowl-shaped clutch cover that contains the pressure plate assem-

bly. The pressure plate assembly consists of springs, release levers and the pressure plate itself. This is a disc usually made of cast iron, with a smooth surface that faces the flywheel. Between the flywheel and the pressure plate is the clutch disc. Pressure from the springs clamps the clutch disc, which has a friction facing on both sides, between the pressure plate and flywheel.

There is a bushing or bearing mounted in the end of the crankshaft or the center of the flywheel that supports the end of the transmission input shaft. The clutch disc itself slides on splines on the input shaft, and when clamped between the flywheel and pressure plate, transmits power to the input shaft when the clutch is engaged. When the pedal is depressed, the release levers in the center of the cover assembly pull the pressure plate away from the clutch disc and allow the flywheel to spin without the disc or input shaft turning. The release levers are pressed by the throwout bearing, which is moved by the throwout lever that extends outside the clutch housing (usually called a bell housing due to its shape). The clutch pedal activates the throwout lever mechanically through levers, links and rods; or hydraulically, with a master cylinder at the clutch pedal and a slave cylinder to activate the throwout lever. Sometimes this slave cylinder is integral with the throwout bearing and they must be replaced as a unit.

Clutches wear out because the friction material on the clutch disc wears away during operation, either through normal wear or abuse such as riding the clutch pedal. When the clutch disc is replaced, it is recommended that the cover assembly, throwout bearing and pilot bearing be replaced as well. The flywheel should also be examined, and if any heat cracking or rough spots are



Components of a typical clutch assembly. The clutch may be actuated by a cable, mechanical linkage or a hydraulic system.

apparent, it should be resurfaced. This is also a good time to check the condition of the rear crankshaft seal and transmission input shaft seal, since transmission removal is required to replace them.

Clutches for most vehicle applications are available both new and remanufactured, with the new units usually being offered as a complete set containing all of the components needed. Some customers will insist on only putting new components into a vehicle while others may wish to save money by only replacing the worn part with a rebuilt unit. Whichever option they decide upon they should be made aware of the need to check everything else related to clutch operation, such as the flywheel, input shaft and clutch linkage. Very often complaints of clutch chatter or grab on engagement can be traced

to poor flywheel condition or an input shaft that does not allow the disc to slide freely. A reminder to check axle halfshafts and universal joints can also boost your sales as well as save the customer another trip. You may also want to remind DIY customers about the need for a clutch disc alignment tool to facilitate transmission installation.

AUTOMATIC TRANSMISSIONS AND TRANSAXLES

Not everyone can or wants to shift a manual transmission, especially if a self-shifting transmission is available. In fact, more than 90% of the cars sold in the U.S. today are equipped with automatic transmissions or transaxles. The modern automatic transmission combines a torque converter and a planetary gearset transmission. A torque converter is a fluid-coupling device, similar to

two fans facing each other in a closed housing filled with oil. Turning one will make the other turn, although if the driven half is held still, the driving half will still be able to turn, although with some resistance. With refinements, the torque converter not only transfers but also multiplies torque.

Most converters also have a lockup feature built into them for better fuel economy. In an unlocked converter the engine spins the drive section at a faster rate than the driven section due to the load of the drivetrain. When a predetermined speed and throttle opening is reached, the PCM activates a Torque Converter Clutch, or TCC solenoid, which locks the two sections of the converter together, eliminating any slippage. Non-electronically controlled transmissions with lockup converters could sometimes get into a condition where the converter would lock and unlock very rapidly while under a load. This could lead some people to misdiagnose it as a misfire or skip in the engine, and it could also lead to rapid failure of the lockup clutch linings.

While a torque converter could be used by itself, the torque multiplication effect would be inadequate for reasonable acceleration. A planetary gearset — a sun gear, surrounded by three or four planet gears, inside an internal gear — helps to solve the problem of inadequate torque multiplication. By locking and unlocking various bands, the planetary gearsets can produce varying torque multiplications and road speeds. Gearset selection has traditionally been performed hydraulically, with a pump and valves controlling the bands and clutches, however, electronic control is now being used extensively. The PCM or TCM (Transmission Control Module) unit senses engine load and road speed and selects gears through the use of solenoid valves controlling the bands.

Older vehicles may also use a vacuum diaphragm called a modulator valve to downshift the transmission when a load on the engine is detected, such as when accelerating from cruising speed. This valve is connected to intake manifold vacuum and in some cases when the diaphragm goes bad it allows transmission fluid to be drawn into the manifold and burned.

Aftermarket parts availability for automatic transmissions is usually limited to bearings and seals, filter kits, solenoids and torque converters, although major and minor rebuild kits are produced by non-OEMs. If your facility handles transmission internals such as gears, shafts, kits etc., be sure you have all the necessary information before trying to order any parts. Most transmissions have some sort of ID tag or a number stamped into the case casting.

The fluid used in automatic transmissions has also changed in recent years. In the past, Dexron II or Dexron III was used in all but Ford applications, which used Type F. Chrysler and Ford, as well as some foreign manufacturers, have started using different fluids, so be sure to ask your customer what the vehicle requires before selling fluids. If they are unsure, the information can usually be found in the owner's manual, a lubrication specification chart or sometimes stamped right on the

transmission fluid dipstick. The consequences of selling the wrong fluids can be unpleasant and expensive for everyone involved.

DRIVETRAIN COMPONENTS

There are many ways to get power from the transmission to the wheels. In the traditional front engine, rear-wheel drive vehicle, a drive or propeller shaft connects the transmission output shaft to the differential. With a live axle, two axle shafts extend from the differential, through solid tubes bolted to the differential housing and then to the wheels. If rear independent suspension is used, the power is transmitted from the differential to the wheels by halfshafts, the same type of shafts that transmit power from the transaxle to the front wheels in a front-wheel drive vehicle.

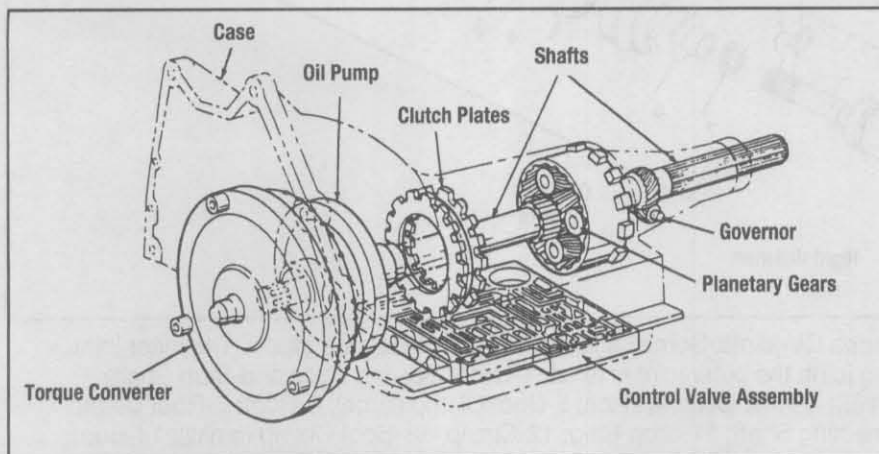
Universal joints are used to allow movement between a rotating shaft and a fixed point, such as between the driveshaft and the transmission output shaft. A simple universal joint combines a pair of yokes connected by a cross, with a bearing cap used where the cross is attached to the yoke. The yokes can pivot on the cross at 90 degrees, thus allowing movement in a full circle. The transmission end of a driveshaft also has a splined slip yoke where it joins the transmission, to allow the shaft to lengthen or shorten with suspension

movement.

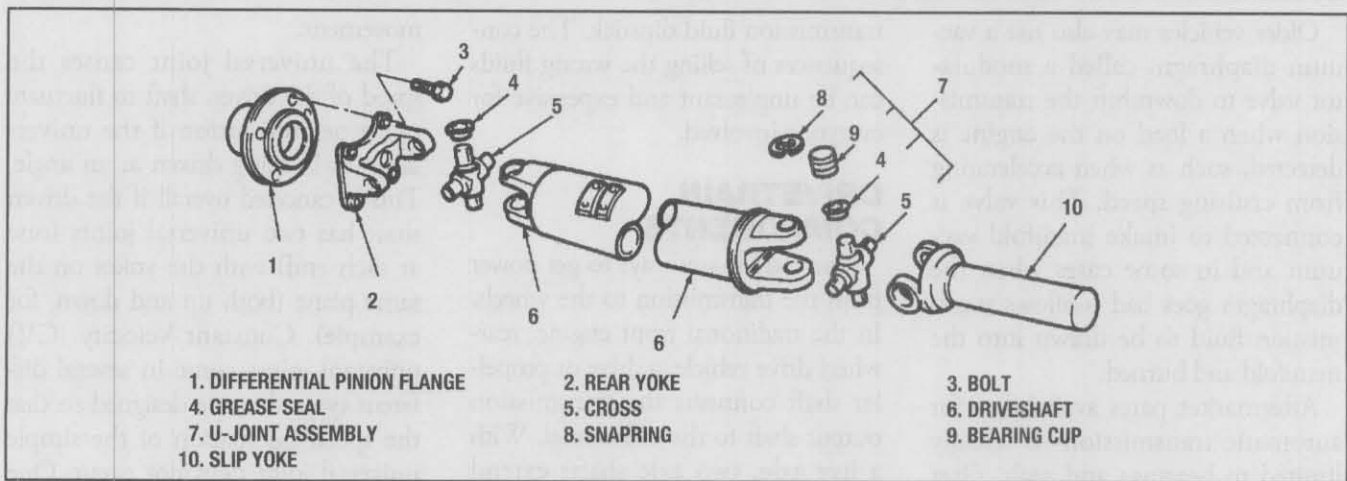
The universal joint causes the speed of the driven shaft to fluctuate twice per revolution if the universal joint is being driven at an angle. This is canceled overall if the driven shaft has two universal joints (one at each end) with the yokes on the same plane (both up and down, for example). Constant Velocity (CV) universal joints come in several different types, but are designed so that the speed fluctuation of the simple universal joint does not occur. One type, for example, combines two simple joints to cancel the fluctuations internally. In applications where the driveshaft is in two or more pieces, a support bearing assembly is used at each section joint. These consist of a metal bracket with a hard rubber insert in the center into which a ball type bearing fits. The bearing is a tight fit on the shaft and allows rotational movement, while the rubber section allows for minor up-and-down and side-to-side movement. The failure point on these is often the rubber portion, which then allows the shaft to whip, causing excess vibration.

Universal joints fail most often due to lack of lubrication. Unfortunately, most OEM joints are not equipped with grease fittings. For those that are, simple preventive maintenance makes a world of difference in how long driveline components last. If a customer brings you an old U-joint that has rusty or powdered bearings, and the joint is equipped with a grease fitting, it was not maintained. If they bring you a joint where the cross or caps are broken, it's outright abuse of the vehicle, most likely due to overloading (trucks) or high stress applications such as racing or off road mud bogging or rock crawling.

Front-wheel and four-wheel drive vehicles with independent suspension use an axle halfshaft to transmit drive from the transaxle or dif-



Typical component layout of an automatic transmission. (Courtesy: GM Corp.)



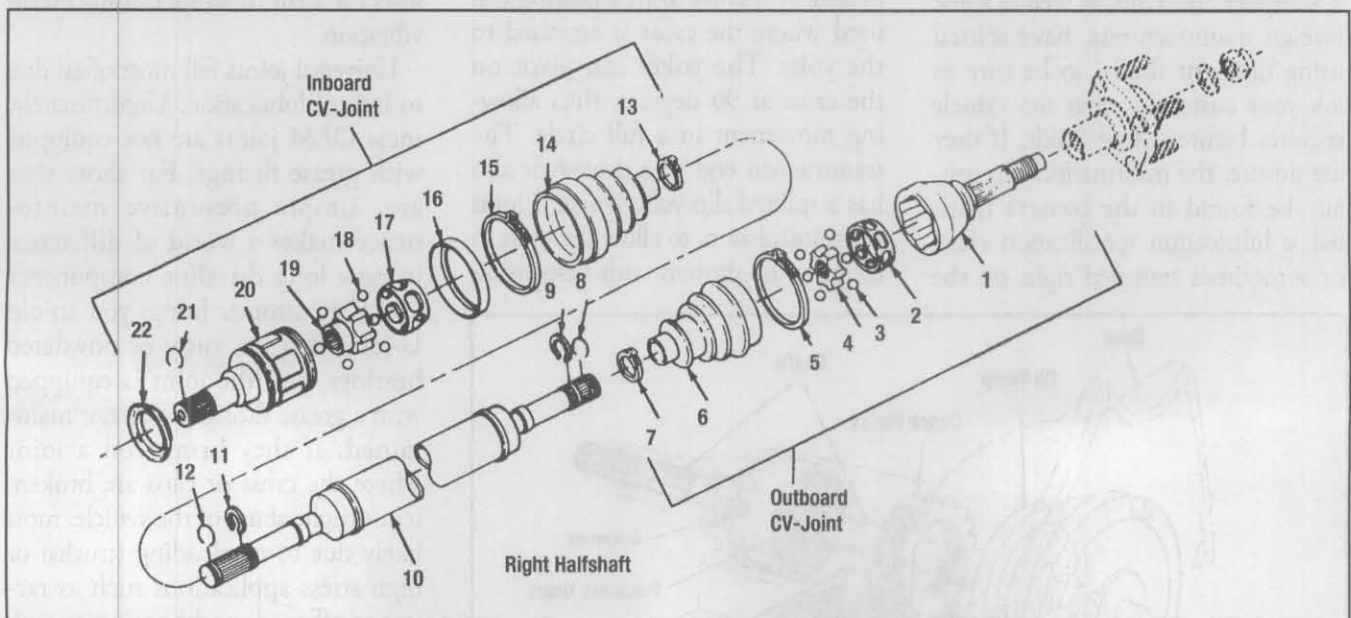
Exploded view of a typical driveshaft. (Courtesy: Ford Motor Co.)

ferential to the wheels. A halfshaft combines both a slip joint to allow for suspension movement and a CV-joint to allow the wheels to steer. The CV-joint used in these applications is different than that used in a rear-wheel drive driveshaft assembly, however. It can best be described as a ball and socket with grooves in both pieces, into which hardened polished balls are fitted. These balls transmit torque and also allow the joint to move freely in all directions. At the

other end of the shaft, in-and-out movement from the transaxle is accomplished using a similar type joint with an elongated socket, that allows the shaft to slide in it, or with a three-lobed universal joint sliding in what is known as a tulip housing.

The CV-joints are enclosed in a rubber accordion-shaped boot and packed with special grease. The most common failure point for CV-joints is this boot, either through road hazard damage or by cracking with age.

When this happens, the grease can leak out and water and dirt can enter, both of which will cause very rapid wear. Because of this and the fact that the shaft must be removed and disassembled to replace a torn boot, many professional installers will replace the entire shaft rather than repack and replace a boot. In many cases, they have no idea how long the boot has been torn or how much wear has taken place so they play it safe and replace the assembly. If you have a



Exploded view of a halfshaft using two Rzeppa CV-joints. Some halfshafts have one Rzeppa tripod. The inner joint, which moves in and out, is called a plunging joint; the outer joint is fixed. 1-Outer Bearing Race and Stub Shaft Assembly; 2-Bearing Cage; 3-Ball Bearings (6); 4-Inner Bearing Race; 5-Boot Clamp (large); 6-Boot; 7-Boot Clamp (small); 8-Circlip; 9-Stop Ring; 10-Interconnecting Shaft; 11-Stop Ring; 12-Circlip; 13-Boot Clamp (small); 14-Boot; 15-Boot Clamp (large); 16-Bearing Retainer; 17-Bearing Cage; 18-Ball Bearings (6); 19-Inner Bearing Race; 20-Outer Bearing Race and Stub Shaft Assembly; 21-Circlip; 22-Dust Deflector.

REMANUFACTURED FRONTWHEEL DRIVE AXLE ASSEMBLIES INSTALLATION TIPS

- 1) Always torque the spindle nut to the proper specification listed in the product catalog.

**CAUTION: DO NOT USE POWER TOOLS TO TORQUE THE SPINDLE NUT!
YOU MAY DAMAGE THE THREADS AS WELL AS THE OUTER CV JOINT
AND WILL VOID THE WARRANTY.**

- 2) Certain vehicles (Ford & Subaru) require special tools for removal and installation of the outer joint in the wheel hub.
- 3) When installing all axles, **DO NOT** let them hang from the transmission at any time. By doing so, you can damage the inboard joint and cause the axle to not function properly. This especially applies to Audi, V.W and Toyota with cross groove style inboard joints that will fall apart if hung in tranny. Also, 95% of Chrysler products have a spring loaded inboard joint instead of the snap ring style that most applications have to lock into transmission. The Chrysler inboard joint will come apart inside the inboard joint, causing this axle to fail. Please handle all Chrysler product C V-shafts with care. Removing them from the box roughly could cause the inboard spring to disconnect and make the axle inoperable.
- 4) **PRIOR TO INSTALLATION, CAREFULLY MATCH THE REPLACEMENT UNIT TO THE OLD UNIT TO VERIFY THE APPLICATION. AT TIMES, AXLES ARE SHIPPED THAT MAY NOT APPEAR THE SAME AS THE ORIGINAL, BUT WILL FUNCTION PROPERLY. PAY ATTENTION TO:**
 - A) Overall compressed length.
 - B) Inner & outer joint stub length and spline count.
 - C) Inner & outer seal diameters.
- 5) Any axle with a circlip on the inner spline should be checked to ensure that no pieces of metal remain in the differential.
- 6) Axles with ABS applications **MUST** be handled with extreme caution. There is a sensor ring around the outer joint that will cause the ABS system to malfunction if damaged.
- 7) Check the transmission fluid for a burnt smell, discoloration, or contamination, and carefully examine the transaxle seal. Replace the fluid and seal if necessary.
- 8) After installing a cir-clip type axle into the transmission, check to ensure the axle is properly retained in the transmission by pulling gently on the inboard housing.
- 9) If the inner joint of an axle was pulled apart or has a ripped or stretched boot, check the condition of the motor mount, all suspension parts, carriage/motor/transmission alignment and unibody or frame damage.

Typical precautionary statement included with a rebuilt axle shaft. Failure to follow instructions can void the warranty.
(Courtesy: CCT Corp.)

customer requesting a replacement boot or a split boot that does not require shaft removal, you could remind them of this fact.

Differential assemblies are required because during a turn, the outside wheel must travel farther than the inside wheel. A straight axle would force one wheel to skid during a turn. The action of the differential allows a difference in speed to take place. Limited slip differentials compensate for the standard differential's tendency to transfer all the torque to the wheel with the least amount of traction, causing it to spin. There are several types of limited slip differentials, but most have internal clutches that restrict excessive turning of one wheel relative to the other.

Under normal use a differential will only require periodic fluid changes throughout the life of the vehicle, but there are exceptions. Leaking seals that allow oil to escape or hard usage such as off roading or snow plowing can take a toll on gears and bearings, and it's not unusual to see the differential cover rust through in areas where road salt is heavily used. The average aftermarket parts store will usually only carry the bearings and seals used in a differential. Gearsets and limited slip components are usually supplied through the OEM or racing and off road specialist suppliers.

There are two types of 4-Wheel Drive (4WD) systems: part-time and full-time. Part-time 4WD is used on trucks and some less-expensive 4WD cars. The driver must select 4WD operation, and the system does not have a center differential to allow for the differing tracks front and rear wheels take in a turn. (Front wheels track wider, requiring more turns than the rear wheels.) Full-time 4WD or all-wheel drive generally utilizes a center differential, sometimes lockable for severe conditions. Another type of full-time 4WD takes effect when the primary driven wheels

begin to slip relative to the secondary driven wheels. One such system uses a silicone fluid that solidifies when it senses shear, caused when one set of wheels starts to spin. Another system senses relative wheel motion electronically, mechanically activating 4WD when slip is detected.

The most common drivetrain items you will likely encounter are universal joints and halfshafts. Universal joints are looked up by application, or by a size chart where the size of the cross and the diameter and type of bearing cap are known. This can be very useful when dealing with a vehicle that has had an axle or transmission swap and the original application is no longer valid. Some vendors offer specific joints for this purpose and have a section in the catalog listing the different combinations such as: #369 + #534 = #429. Driveshaft center support bearings are also a good add on sale if the customer has the shaft out to service a universal joint. When selling a half-shaft, be certain you have all the necessary information. This may include the manufacturer of the shaft, overall length, and whether the vehicle is equipped with ABS. You might also suggest that the customer look at the wheel bearings and brake pads, since they must be gone through or around when removing the shaft.

BRAKES

There are two types of brake systems in use today, disc and drum. Disc brakes, which are more widely used, work by clamping a disc between friction pads (brake pads) held in a caliper. Drum brakes work by pushing brake shoes, covered with friction material called lining, outward against the inside of a brake drum. Disc brakes are favored for their better cooling and resistance to fade. Fade can occur with drum brakes when the drum heats up and expands, requiring more pedal pressure to move the

shoes further out to stay in contact with the drum. Some brake drums have cooling fins cast onto their outer surfaces, but they are still more prone to overheating and fade than even a solid brake disc rotor. Disc brake cooling can also be improved by ventilation, via internal cooling slots in the rotor. Brake systems can either be 4-wheel disc, 4-wheel drum, or front disc/rear drum. Four-wheel-disc systems are becoming more common, but the front disc/rear drum combination is still the most widely used braking system on cars and light trucks, mainly because it is easier and cheaper to facilitate a parking brake on a drum type rather than a disc brake. Four-wheel drum systems are now found only on older vehicles.

Modern brake systems are hydraulic, meaning that the braking force is transmitted from brake pedal to the braking surface by hydraulic brake fluid. The pedal pushes a piston in a cylinder, called the master cylinder, which contains brake fluid. Because liquids cannot be compressed, the fluid transfers pressure as movement through brake lines and hoses to each caliper or wheel cylinder. The brake lines are made of high quality, specially prepared steel tubing, and rubber flex hoses are used to allow suspension movement where needed. The hydraulic pressure forces out piston(s) from the wheel cylinders and/or calipers, pushing the brake shoes against the drum or the pads against the disc. Return springs pull the shoes away from the drums when the brake pedal is released while disc brake pads are simply pulled back a few thousandths of an inch by seal tension.

The fluid used is usually mineral based, the two most common being DOT 3 and DOT 4. This DOT (Department Of Transportation) rating signifies the boiling

point of the fluid, with the 4 designation usually referred to as heavy duty. Mineral fluids absorb moisture from the air and over time this will lower the boiling point of either DOT 3 or DOT 4 fluid, so it should only be sold in sealed containers. Mineral oil is also harmful to painted surfaces if it comes into contact with them for too long a period of time.

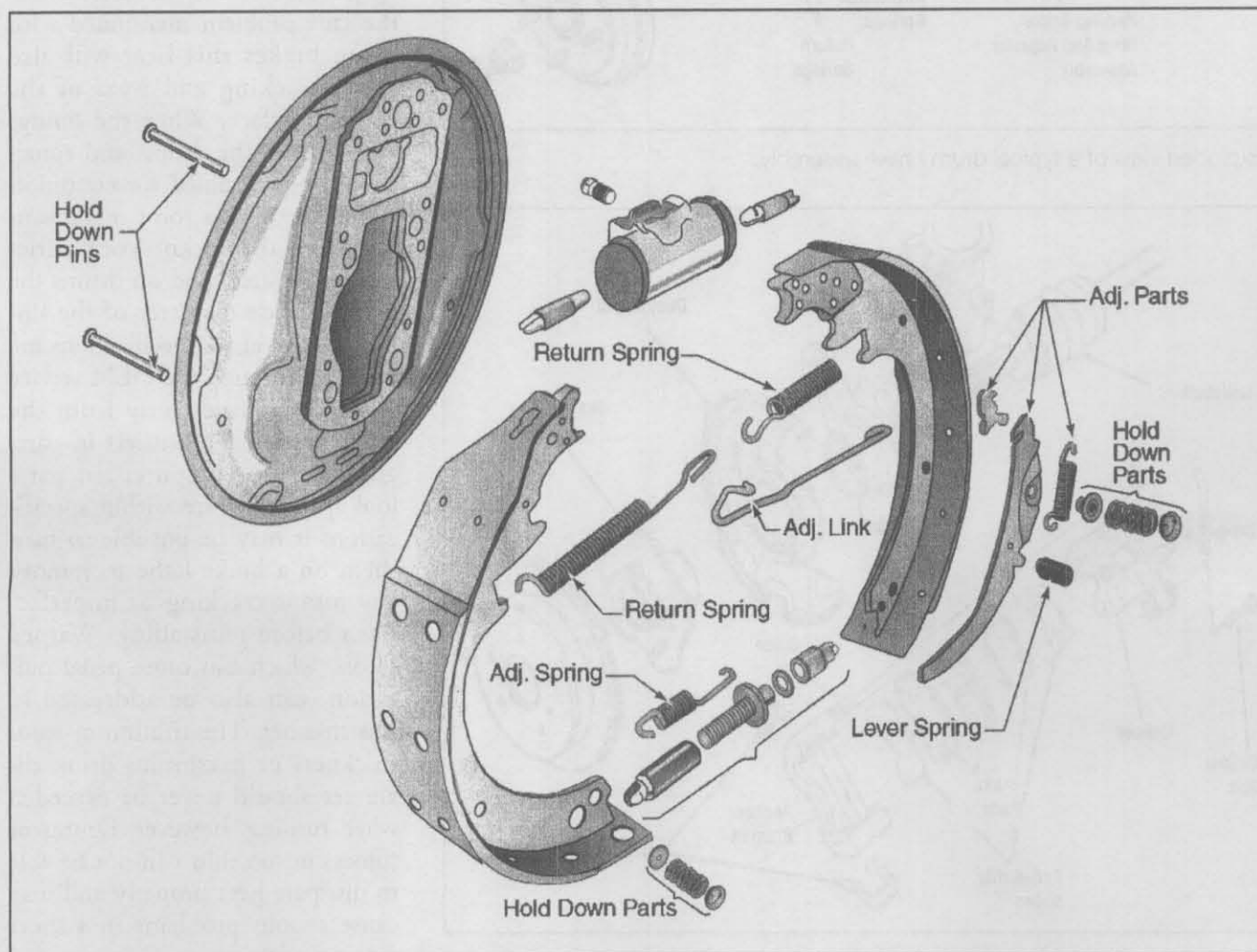
There is also a DOT 5 fluid classification, which is silicone based. It will not absorb water but it is not compatible with mineral based oils and should never be mixed. It is most often used in military vehicles that operate in harsh conditions, and in some high end custom cars and motorcycles due to

the fact that it won't harm paint.

While they are both part of the same overall system, brakes can be divided into two subsystems. The Foundation Brakes, composed of the actual friction materials and related hardware as well as drums and rotors, and the Actuation System. The actuation system comprises all of the hydraulic or mechanical components that put the friction material into contact with the drum or rotor, including lines, cylinders, and linkage and cables for parking brake operation. We'll start with the foundation brakes, as these parts are the most commonly replaced.

Foundation Brakes/Wheel End Systems

The main components of a drum brake system are the backing plate, brake shoes, wheel cylinder, return springs, self-adjuster mechanism, and parking brake linkage. The entire assembly is mounted to the backing plate, which is then mounted to the axle. The wheel cylinder is bolted to the backing plate and the shoes are held on with some sort of spring clip to allow them to move in and out. The return springs pull the shoes back after the brake pedal is released. The adjuster keeps the shoes in close proximity to the drum so excess travel is not required on application. Parking



Close up view of a typical drum brake assembly, showing detail of self-adjuster screw and linkage.
(Courtesy: Raybestos Brake Co.)

brake linkage usually consists of a strut bar and lever that connects to the parking brake cable. When the cable is pulled the lever moves

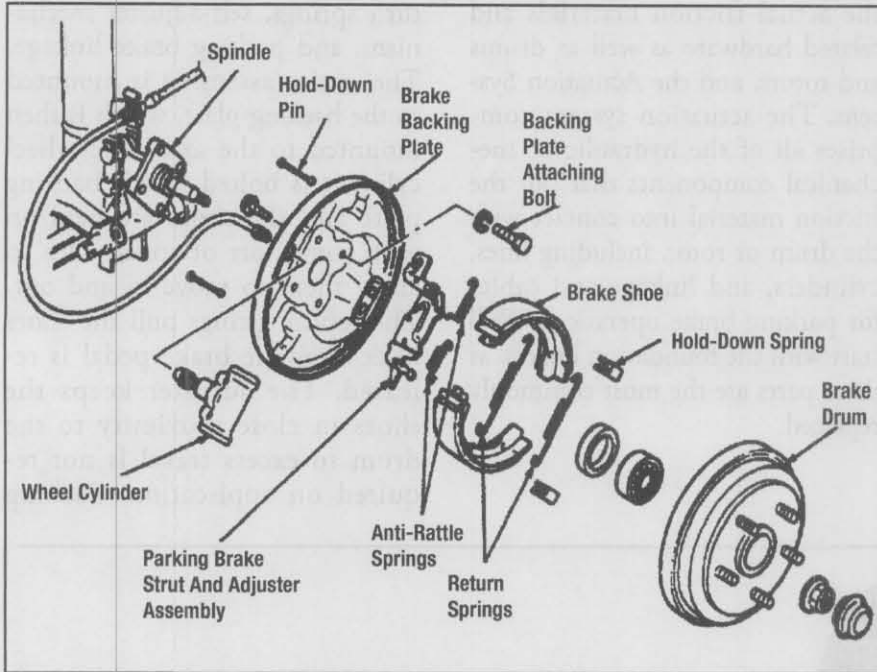
the strut bar that pushes one shoe, most often the front, into contact with the drum.

The effectiveness of some drum

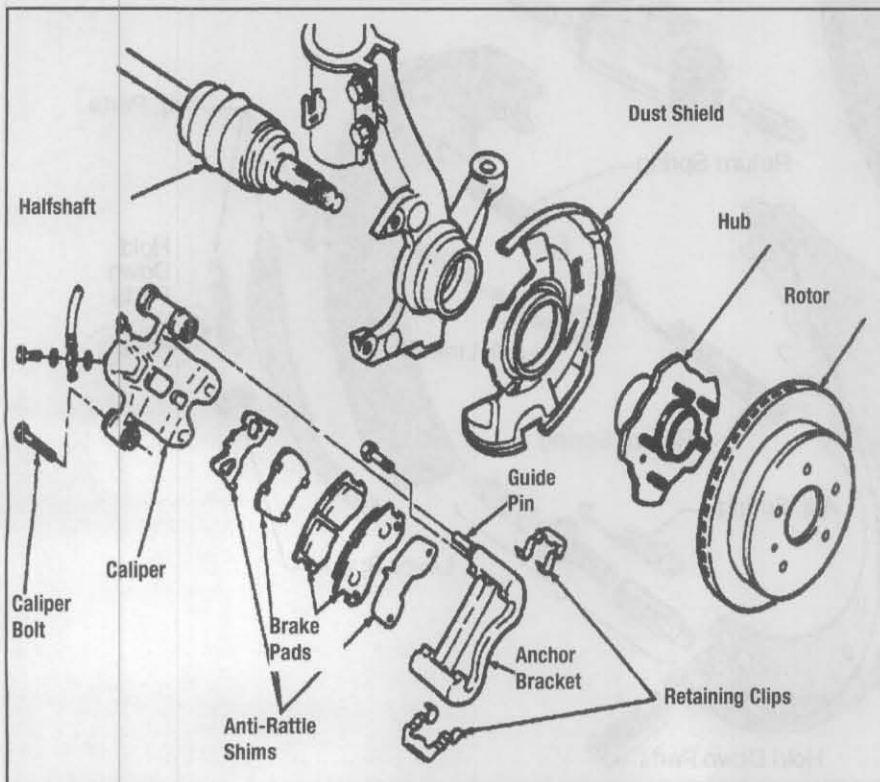
brake systems is improved by a self-energizing design that uses the rotation of the brake drum to force the shoes against the drum surface. In this system, one shoe has a brake lining that is longer than the other. Modern drum brakes are also self-adjusting, automatically compensating for brake lining wear. A small lever moves the adjuster star wheel when the brakes are applied with the vehicle moving in reverse.

Brake drums and rotors are most often made of iron or a similar alloy, which has excellent heat dissipating properties. As the brakes are applied, the friction of the linings against the drum or rotor causes large amounts of heat to be generated, and in addition to the fade problem mentioned with drum brakes this heat will also cause cracking and wear of the contact surface. When the linings are changed the drums and rotors should be examined for condition and wear. With a rotor this means measuring the thickness of the friction swept area, and on drums the overall inside diameter of the lining contact area. Specifications are available through the OEM service channels or frequently from the brake parts manufacturers in parts guides or on computerized parts lookup. If they are within specifications it may be possible to turn them on a brake lathe to remove any minor cracking or imperfections before reinstalling. Warped rotors, which can cause pedal pulsation, can also be addressed in this manner. The minimum rotor thickness or maximum drum diameter should never be exceeded when turning, however. Drums or rotors cut too thin will not be able to dissipate heat properly and may cause serious problems in a short amount of time.

Brake service is probably the most common under car service



Exploded view of a typical drum brake assembly.



Typical disc brake assembly as used on a front-wheel drive vehicle. This is an outboard mounted rotor; it is mounted to the outer side of the hub and can be removed without removing the hub.

work performed. Every time the brakes are applied the linings are worn away by a small amount and over time become too thin to be effective. If left in service long enough the linings will wear away completely and metal-to-metal contact between the drum/rotor and brake pad backing will occur, which usually ruins the drum/rotor. It's also important to remember that as linings become thinner they lose their ability to dissipate heat efficiently. When this happens braking efficiency can be lost and excess heat will be transferred to the brake caliper or wheel cylinder pistons causing them to fail prematurely. With that in mind you can remind your customer that just because there is 'still some meat left' on that brake pad or shoe, it might not be a good idea to reuse it. A dollar spent in preventive maintenance can often save much more than that in repair bills.

Another overlooked area in drum brake service is the condition of the return and hold-down springs. While they may look good, by the time lining replacement is required they have been subjected to thousands of heat and cooling cycles. This will cause them to lose tension over time and eventually break; therefore a new spring/hardware kit should always be suggested when selling linings. This applies to the self-adjuster hardware as well, and it should be noted that the star wheel adjuster's threads are prone to seizing, especially in areas where road salt is used. When this happens the brakes can wear to the point that the excess travel needed to make them apply not only causes a loss of braking power but can also lead to the adjusters themselves dropping out of place. Once this occurs, damage to the drums and other hardware is likely as well as complete loss of braking on that

wheel. A small amount of anti-seize lube or brake grease used on the threads of the adjuster will prevent this.

The condition of the backing plate should also be checked whenever brake service is performed. In areas where road salt is used it's not uncommon for them to rust away to the point of being unserviceable. On vehicles where the plate only serves as a dust shield this will not affect brake operation, but if any of the foundation brake components are mounted to the plate, catastrophic failure can occur. The plate could become weakened due to rust until one final application causes the wheel cylinder to be torn out of place by the energizing action of the shoes. This would then cause the steel hydraulic line to fracture with an ensuing loss of fluid, resulting in total failure of that brake circuit.

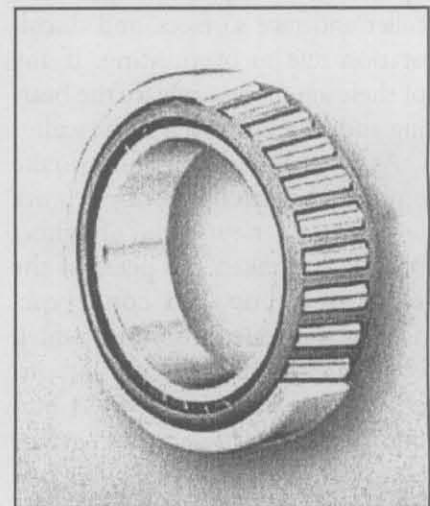
Disc brakes have far fewer moving parts and components than drum brakes, and the majority of them are covered in the hydraulic section of this book. A few things to remember however, are caliper mounting points and associated hardware. Whenever the caliper is removed for pad replacement the mounting bolts, slide pins, or sliding points should all be cleaned and inspected and well lubed before reassembly. Failure to do so will result in poor operation and shortened lining life.

Wheel Bearings

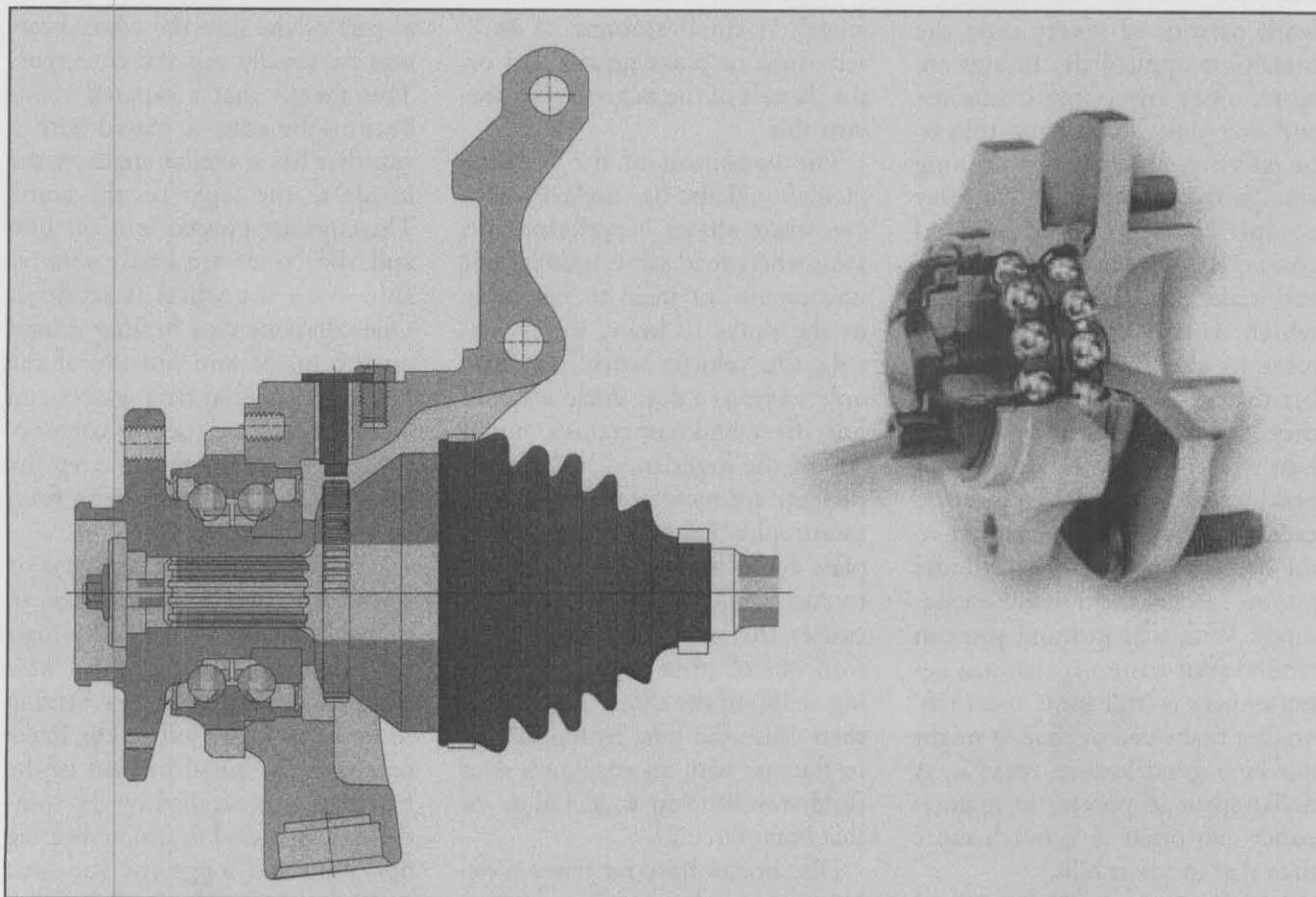
While not technically part of the braking system, wheel bearings and seals are an integral part of it. Whenever service work is performed to one, the other must usually be gone through to access the other. Wheel bearings are necessary to reduce friction between the axle spindle and the hub that the drum/rotor mounts to. On brakes where the drum/rotor is cast

as part of the hub the wheel bearings are usually cup and cone type. This means that a tapered roller bearing-the cone-is mated with a cup that has a similar angle on the inside as the taper on the cone. The cups are pressed into the hub and the cones are easily removable when the wheel is serviced. One cup/cone type bearing is used on the inside and outside of the hub, and a special tang washer and locking collar are used in conjunction with a cotter pin to keep the spindle nut that retains them from moving once installed.

Whenever they are removed or replaced, wheel bearings need to be packed with high quality high melting point grease and a new seal installed on the inner bearing to keep the grease off of the brake components. Initial preload of the bearings, as controlled by the spindle nut, is critical to proper bearing operation and longevity. Too little preload and the wheel will be loose on the spindle causing poor brake operation and a wobbly wheel. Too much and the bearing can overheat and fail quickly. Cup and cone bearings should be cleaned and inspected every time the wheel is ser-



Cutaway view of a tapered roller bearing showing the inner or cone part mated to the outer cup portion of the bearing. (Courtesy SKF Corp.)



The illustration on the left shows a sealed hub unit installed on a spindle. You can see the axle splines where they pass through the hub, and also the ABS tone ring and sensor, which in this case are not integral with the hub. The tone ring is mounted to the CV-joint housing and the sensor is bolted into the upper portion of the spindle housing. The illustration on the right is a cutaway of the hub unit itself. (Courtesy SKF Corp.)

vised. Signs of failure include rough operation, pitting or galling of the roller and race surfaces, and discoloration due to overheating. If any of these are present replace the bearing and the cup as well as the seal.

As front wheel drive disc brake equipped vehicles became more common, a new type of wheel bearing has taken the place of the traditional cup and cone type. This is the sealed hub unit, which combines the bearings and hub including the wheel studs/ bolts into one part. With this type of wheel end system, a single or double row roller or ball bearing is pressed into a housing and the center hub then pressed into the inside race of the bearing. This hub will also have splines machined into the inner

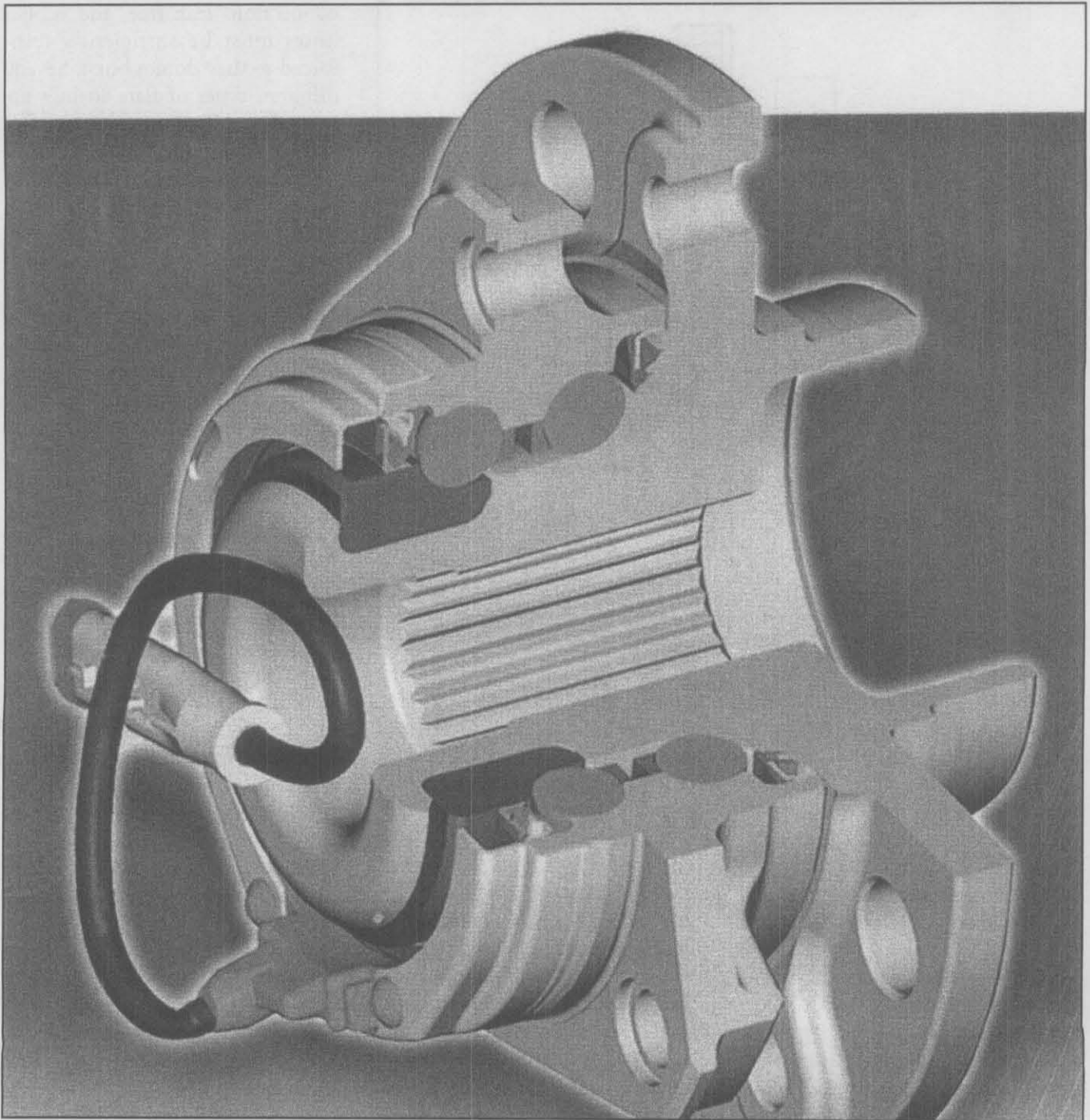
hole that mate with the splines on the drive axle in drive axle applications. The entire unit is then bolted directly to the spindle housing or axle.

The big advantage to this type bearing is that they require no service until replacement is needed since the bearings are permanently lubed and sealed. The disadvantage is that they can be very expensive to replace compared to traditional cup and cone bearings, and they still require proper torquing of the axle nut or premature failure can occur. Many newer vehicles equipped with ABS also incorporate the sensor and tone ring into the hub assembly. While this helps to shield them from outside contamination, it also means that an

ABS problem may require a hub assembly replacement.

Actuation/Hydraulic Systems

Master cylinders used in vehicles built since the middle 1960s are dual chamber split-type cylinders, with one end or chamber of the cylinder controlling two wheels and the other controlling the remaining two wheels. In the event of a ruptured line or leaking caliper or wheel cylinder, there will still be some braking power available from the other chamber of the cylinder but it will be greatly reduced. Early dual chamber systems were split front-to-rear, but since most vehicle stopping power is supplied by the front brakes, if there is a prob-



Closeup cutaway view of a sealed hub unit with integrated ABS sensor and tone ring. (Courtesy: SKF Corp.)

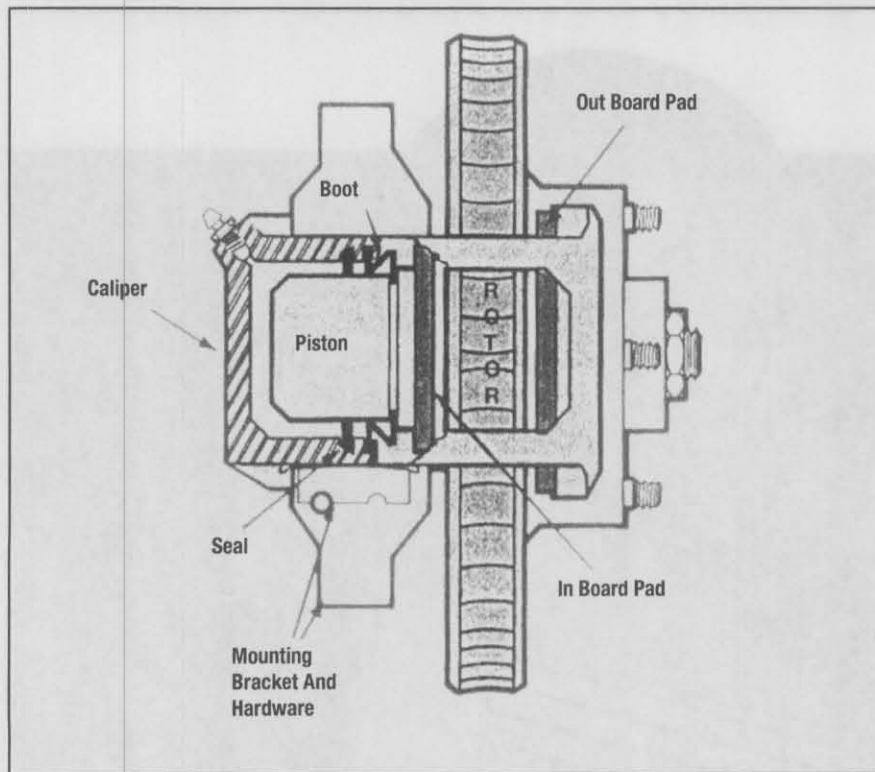
lem in the front brake circuit, there is very little stopping power left. Modern brake systems are split diagonally, with one front wheel and the opposite rear wheel on each circuit.

When brake system failure occurs it will cause the pedal to sink to the floor and illuminate a brake warning light on the dashboard.

This light may also be connected to a brake fluid level sensor that warns the driver if fluid needs to be added to the master cylinder fluid reservoir. If a customer complains that they have to constantly top off the fluid reservoir you should remind them to check all lines, wheel cylinders and calipers for signs of leakage. It is also possi-

ble for the master cylinder rear seal to leak fluid back into the power booster where it cannot be easily seen. Normal disc brake pad wear will also cause a gradual lowering of the fluid level in the reservoir due to the increased distance the caliper pistons have traveled out of their bores.

A proportioning valve is located



Cutaway view of a typical disc brake assembly.
(Courtesy: King Kaliper Corp.)

in the brake line between the front and rear brakes, which acts to balance brake force between them. It works by limiting the flow of fluid to the rear brakes until a certain pressure or 'split point' is reached. Above this point, pressure is allowed to rise at only a portion of that applied to the front. This is done to keep the rear wheels from locking during a panic stop, since the front wheels perform a greater share of the braking. Some proportioning valves may also have a link between the valve and the load-carrying portion of the body, such as on a pickup truck. As the load increases, the amount of brake limiting is decreased by the link moving a valve within the proportioning valve.

The proportioning valve should not be confused with a metering valve. The metering valve is used to delay the delivery of fluid to the front disc brake calipers on a disc/drum brake vehicle. The reason

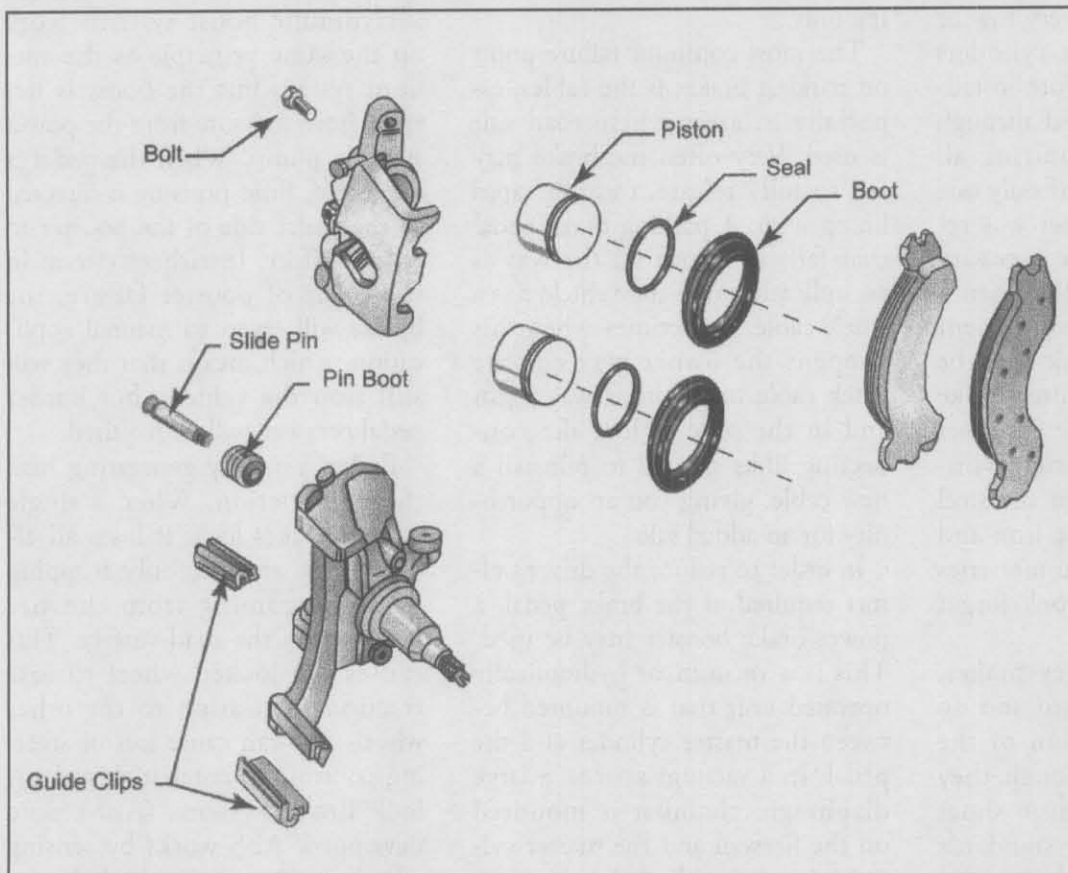
for this is the difference in distance that the wheel cylinders must move the drum brake shoes in relation to the movement of the disc caliper pistons. The brake pads on the front have only a small amount of clearance between them and the rotor, so application is almost instantaneous when the pedal is depressed. Drum brake shoes must travel farther before they contact the drum, so in order to get a uniform application, the metering valve holds off pressure until a certain point is reached. When the split point is reached the metering valve opens, and the rear brake shoes have then traveled far enough so that both front and rear brakes apply at the same time.

The lines and hoses used in a hydraulic system must be able to handle high pressures, as much as 2000 psi, through repeated cycles without rupturing or cracking. Special double flared ends and threaded fittings are used to keep

connections leak free, and rubber hoses must be sufficiently reinforced so they do not burst. Several different types of flare fittings are used depending on the manufacturer and country of origin. European and Japanese manufacturers use a bubble type flare that crushes and conforms to a cone inside the component to which it is connected, and the threads are metric. U.S. manufactured vehicles used to use an inverted cone shaped double flare almost exclusively, but it is now not unusual to find a mixture of both types even on domestically built cars.

The typical steel lines available in the aftermarket are pre-flared, come in a variety of lengths and diameters and must be bent to the desired shape by the customer. Adaptors are available for applications where the OEM line size and fitting size do not match up to standard sizes or where it is necessary to convert from a bubble flare to a standard double flare line. If a customer is repairing a rusted or broken steel line it is important to use the right fittings and connectors. Every connection should be made using a tubing cutter and flaring tool, the proper sized flar-nuts and a threaded union. Compression type unions and copper or aluminum tubing are not strong enough to withstand repeated use, and are also not safety inspection legal.

Wheel cylinders used in drum brakes are small dual piston slave cylinders that push outward on one end of each brake shoe. They consist of a casting with a smooth finished bore, a line connection and a bleeder valve. Cup type seals are inserted into either end, and the pistons go in after the seals. An outer boot with a small hole in the center allows a pushrod to fit into the piston and seals the cylinder bore from dust. The pushrod is



Exploded view of a typical twin piston caliper. (Courtesy: Raybestos Brake Co.)

notched to fit the shoe and pushes the shoes outward when fluid pressure moves the pistons.

There are three general types of disc brake calipers: the fixed caliper, the sliding caliper and the floating caliper. The fixed caliper design contains one or two pistons positioned on each side of the rotor. With this arrangement, the caliper is rigidly attached to the spindle and the pads are applied with equal hydraulic pressure from both sides. The floating caliper design uses an adapter, or anchor plate, that is bolted to the spindle. The caliper floats laterally across a pair of special bolts that are screwed into the adapter. As hydraulic pressure is applied to the piston(s), the inboard pad is forced against the rotor. This pressure causes the caliper to move inboard until an equal pressure is applied by the outside pad to the outer disc

surface. The sliding caliper operates similarly to the floating design, however, it attaches to the anchor plate using only one attachment point.

Because they are exposed to the intense heat from brake friction as well as dust and dirt, it's important that the piston boots are not ripped or torn. Over extension of the piston due to pad wear and deterioration due to age can cause the boot to fail. When this happens dirt will get inside between the piston and the bore causing rapid wear and failure due to leakage. The other great destroyer of calipers, and any component of the system in contact with brake fluid, is corrosion. As mentioned earlier in this chapter, brake fluid is hygroscopic, meaning that it absorbs water from the air. If enough moisture collects in the system it will cause rust and corrosion,

which manifests itself as sludge in the cylinder and caliper bores as well as ABS solenoids and valves. This will then cause the pistons to stick, often in the extended position, leading to rapid brake wear. The customer who chooses to just push the piston back into the bore rather than replacing or rebuilding the caliper is only inviting trouble.

When floating and sliding caliper disc brake assemblies are serviced, the pins, bushings and slides should be cleaned and well lubricated. Otherwise, the caliper could seize on the pins or slides and cause the inboard

pad next to the caliper piston to wear out long before the outboard pad.

Hydraulic brake components such as master cylinders and calipers are widely available in both new and remanufactured versions. In the past, it was common for the technician to buy a rebuild kit for a wheel or master cylinder and do it himself, but with the increasing use of alloy cylinders rather than cast iron, this is not always an option. Also, the relative price of buying a remanufactured unit and installing it is more cost and time efficient than in-shop rebuilding.

Whenever the hydraulic system is opened, either to replace a component or because of a broken line, all air must be bled from the system after repairs are made. Since air will compress and fluid won't it must be removed or the pedal will

have a spongy feel, or very low or no pedal at all. Master cylinders must be bench bled before installing or air can be pushed through the whole system, requiring all four wheels to be bled. If only one wheel cylinder or caliper was replaced it should only be necessary to bleed that one wheel. When a line is replaced, any component downstream of the break must be bled. Brake hoses and lines make good add on sales to the customer replacing wheel or master cylinders. It's not unusual for the steel flarenuts to rust to the line and twist off when the customer tries to loosen them, and don't forget the brake fluid.

Parking, or emergency brakes, are mechanically operated and do not require the function of the hydraulic system, although they usually activate the same shoes or pads. Federal safety standards require at least one axle to have brakes that operate independently of the hydraulic system in case of system failure or for when the vehicle is parked. There are some supplemental brake locks that work by keeping pressure in the hydraulic lines after the pedal is released but these are not meant to be used for long term parking. They are most often found on vehicles such as wreckers and industrial equipment.

In a typical front disc/rear drum system, the parking function is built into the rear drum brakes by means of a lever attached to the rear brake shoe and activated by a cable. When the brakes are set the cable pulls the lever forward, which pushes a crossbar between the shoes that moves the front shoe against the drum. Vehicles with four-wheel disc brakes may have a cam behind the caliper piston that is operated by a lever and cable or they may have a separate, smaller cable activated drum brake inside the rear rotor that is used for park-

ing only.

The most common failure point on parking brakes is the cables, especially in areas where road salt is used. Very often the brake may fail to fully release, causing rapid lining wear. A parking brake pedal that fails to return all the way is an indication that the vehicle has a stuck cable. Sometimes when this happens the owner may cut the stuck cable to get underway again and in the process lose the connecting links needed to reinstall a new cable, giving you an opportunity for an added sale.

In order to reduce the driver's effort required at the brake pedal, a power brake booster may be used. This is a vacuum or hydraulically operated unit that is mounted between the master cylinder and the pedal. In a vacuum system, a large diaphragm chamber is mounted on the firewall and the master cylinder is mounted to the chamber. The chamber is connected to intake manifold vacuum on the side nearest the cylinder and the back side is open to atmospheric pressure. Because atmospheric pressure on the pedal side is greater than that on the vacuum side, when the pedal is depressed, reduced effort is required to apply the master cylinder. The line between the manifold and booster must be strong enough to not collapse under vacuum and have a check valve installed, usually at the booster end of the line. The valve keeps residual pressure in the booster when the engine is off and also keeps fuel vapors out of the booster at the same time.

The most common cause of booster failure is a faulty master cylinder seal leaking brake fluid back into the booster and destroying the diaphragm. If you have a customer replacing either part by itself, you should suggest that the other be checked for damage as well.

Hydraulic boost systems work on the same principle as the vacuum system but the boost is derived from pressure from the power steering pump. When the pedal is depressed, fluid pressure is directed to the pedal side of the booster to reduce effort. In either system, in the event of booster failure, the brakes will revert to manual application, which means that they will still stop the vehicle, but harder pedal pressure will be required.

Brakes work by generating heat through friction. When a single wheel's brakes lock, it loses all effectiveness and the only stopping power is coming from the tire skidding on the road surface. This causes the locked wheel to lose traction in relation to the other wheels and can cause loss of steering control. To combat this, Anti-lock Brake Systems (ABS) were developed. ABS works by sensing wheel speed at each wheel. If one slows down faster in relation to the others, the system will modulate application pressure to that wheel to keep it from locking.

The description of a typical ABS system begins at the wheel, where you will find a toothed steel ring, called a tone ring, or sensor ring, which rotates with the wheel. This ring can be either cast as part of the drum or rotor, a separate piece that is pressed on, sometimes to the halfshaft, or even built into the hub/wheel bearing assembly. Next is a sensor mounted in close proximity to the tone ring. This is a permanent magnet sensor that senses the teeth of the tone ring as they pass by and sends a signal to the ABS control module, telling it how fast the wheel is spinning. The module uses this input and possibly others from a powertrain control module to monitor the brake system. The brake lines themselves will have a solenoid of some type installed, which the module ac-

tivates to control brake pressure. This is usually located under the vehicle hood close to the master cylinder, so all the wheels are controlled from one point.

As the brakes are applied and the vehicle slows down, if one wheel slows much faster than the others, the sensor will relay this information to the ABS module. It will then activate that wheel's solenoid, which releases and reapplies pressure to keep the wheel spinning at the same speed as the others. This release and reapply can happen six times a second or more, so the driver may not notice any difference in pedal feel, however they may hear a strange growling or grinding type of noise during an ABS event. This is normal and should not be confused with the grinding noise made by worn brake linings.

All ABS systems are designed to revert to normal braking in the event of a failure of the ABS and to have an indicator light come on to inform the driver if this happens. Perhaps the best ABS advice you can give to a customer is to keep the rest of their braking system in good condition. This includes brake linings, as well as regular brake fluid changes. DOT 3 and DOT 4 fluids are mineral based and will absorb moisture over time. If this moisture finds its way into the ABS solenoid valves, it can create corrosion problems and expensive repair bills. Bad wheel bearings or halfshafts can also cause the tone ring to come into contact with the sensor and either destroy it or cause an ABS malfunction.

Brake Complaints

Two of the most common complaints encountered in brake service are pedal pulsation and squeal after new disc pads and rotors are installed. While the technician or customer may swear that the parts

you sold to him are defective, the problem can often be traced to improper installation or selecting the wrong grade of lining. Pulsation is caused by the rotor being warped or out of alignment with the pad surface. As the rotor 'high spot' passes by the caliper piston, it pushes it in. This causes the master cylinder piston to push out on the pedal linkage, causing the pedal to move up and down. While it's not unheard of for rotors to be warped from new or to warp soon after installation, a few other things should be checked as a possible cause.

On outboard mounted or 'hat shaped' rotors that mount on the outer face of the hub, it is essential that the hub surface and the rotor contact face be clean and smooth. Also, the holes for the wheel studs should fit squarely over the stud. If the rotor does not fit perfectly flat on the hub surface, it will not run true to the pad and pulsation will result. On hub and rotor combinations, where the hub complete with lug studs and wheel bearings is cast along with the rotor surface, other factors can cause pulsation. A bent spindle or improperly installed bearing can cause the rotor to be misaligned with the pad surface. Over-torquing or uneven torque on wheel lug nuts can also cause the hub and rotor to distort. Improperly installed or poorly lubricated caliper slides can cause the caliper to become misaligned or bound up on its bracket or pins, allowing the pads to contact the rotor at an angle.

It should also be noted that not all rotors are of the same quality. Some of the less expensive ones can warp in a short period of time due to insufficient cooling or poor materials used in construction. This presents great upsale opportunities to installer and DIY customers alike in terms of both customer

satisfaction and warranty.

Brake pad squeal can be traced to several factors. In some cases, it may be due to the metal backing on the pad chattering on the steel caliper piston. There are shims available for some applications that fit between the pad and piston and help to prevent this. There are also many brands of chemical treatments made to brush or spray on the backside of the pad to reduce noise.

Using the wrong pad and rotor combination can also cause squeal from the pad surface. At one time, brake linings were made from asbestos, which was fairly soft and provided good heat resistance. Asbestos has been replaced by compounds containing things such as graphite, Kevlar and sintered brass or other metals. When this type of pad is used with a rotor of inferior quality or in an application where they are not recommended, squeal can result. Some OEMs are starting to use composite rotor materials that are very sensitive to pad compounds. Many aftermarket manufacturers offer a premium pad lining containing ceramic compounds to combat squeal and to minimize brake dust buildup on alloy wheels. These would be a good upsell to a customer with squeal complaints.

You may also hear complaints of aftermarket brake pad linings not being equal to what was installed as OEM. This is most certainly true, but that doesn't mean that what you or anyone else sells is inferior to the OEM. The customer who complains that the original linings on their vehicle lasted 50,000 miles while the replacements you sold him only lasted 30,000 needs to be reminded that when his vehicle was new every part of that brake system was new! When the brakes were replaced did they pay attention to the rest of the

system? Was every related component checked and inspected and returned to like new condition? If not, then it's not fair to blame one manufacturer's product over another, especially if the customer shops on price as opposed to quality.

Brake pads and linings are available in many different grades and materials, so you should familiarize yourself with what you sell and how it compares to the competition. Some people shop on price alone, and would be satisfied with anything as long as it's cheap, while others are more concerned with safety and longer life from their brakes. High performance cars, and trucks that haul heavy loads or pull a trailer, will benefit from high quality brake linings and components. Also, don't forget to mention any related hardware. Caliper mounting bolts and pins, as well as brake shoe return springs, should all be examined and replaced if at all in doubt. Leaking wheel cylinders and cracked brake hoses and lines should also be replaced. By stressing the safety aspect of brake sales, upselling and related sales will be very easy, and you will be doing yourself and the customer a favor.

SUSPENSION AND STEERING

Suspension

All vehicles need some form of suspension to isolate them from road hazards and enable them to take turns without rolling over or skidding. In a vehicle without some form of suspension, the pounding ride would not only be uncomfortable, but the lack of suspension could make the car hard to control, and in the long run would literally shake the car apart.

All passenger car and light truck suspension systems use some form

of spring to cushion road shocks. One of the oldest commonly used springs is the semi-elliptical leaf spring. The leaf spring is one or more flat bands of steel (or composite material) with a slight downward arch. The springs are generally attached longitudinally to the frame at each end and to the axle in the middle. Bumps deflect the spring and axle upward while the body remains stable. To compensate for the added length this upward deflection causes, a leaf spring is usually connected to the frame by a swinging shackle. If more than one leaf is used, a center bolt of hardened steel is used to hold them together and nylon or Teflon inserts added between the leaves to eliminate noise and wear. Leaf springs in automotive use are normally used at the rear with either a live axle (rear drive) or dead axle (front drive). Some four-wheel drive trucks with live front axles use leaf springs at the front.

NOTE: *If the axle contains a driveshaft in a hollow center, it is called a live axle; if it is a solid beam, it is called a dead axle.*

Leaf springs can also be mounted transversely, attached to the frame at the center and to the suspension at each end. Transverse leaf springs may be used at the front (on some very old Fords) or rear (on some Corvettes).

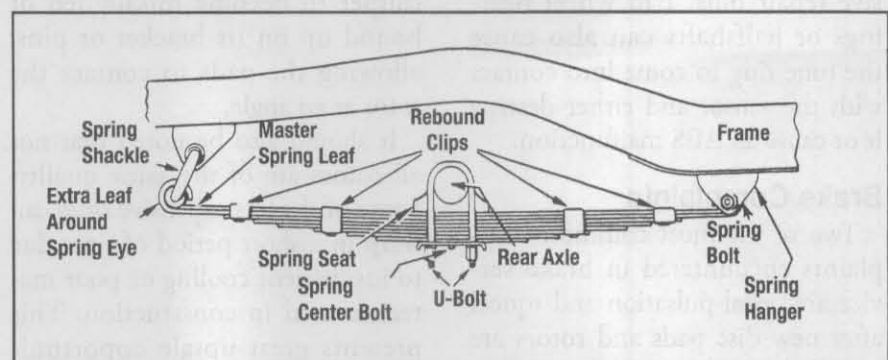
Coil springs are the most com-

mon type of spring used on the modern automobile. They are made from special spring steel rods, heated and wound into a spiral coil. When the coil is compressed by hitting a bump, it will return to its normal length after the load is removed.

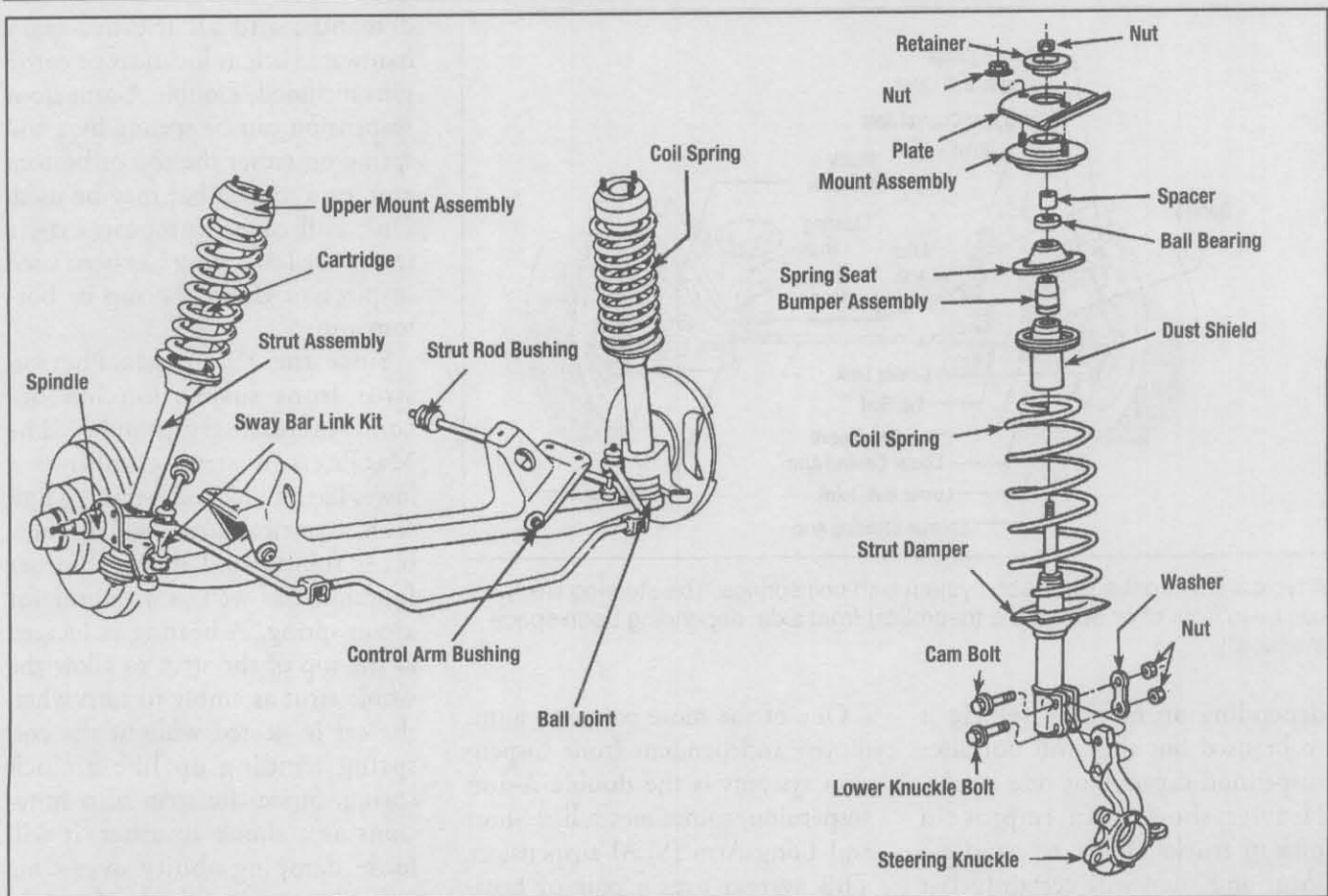
Torsion bar springs, generally called torsion bars, are straight rods of spring steel. One end is fixed to the chassis to prevent twisting; the other end is fitted with a lever arm attached to the suspension arm that acts against the torsion bar. When the wheel hits a bump, the arm is twisted upwards against the resistance of the torsion bar. Torsion bars can be used at either front or rear, and mounted transversely or longitudinally.

Some vehicles use air springs, which use the compressibility of air as the spring medium. These are most often found on heavy-duty trucks but there are a few luxury vehicles that use air springs. They may also be added to light-duty pickups and box trucks as an overload spring to increase carrying capacity. The need for a compressor to maintain ride height, as well as the expense of the air spring itself, limits their wider usage.

Springs and torsion bars generally will not require replacement unless over-stressed by heavy loads and rough road conditions. Leaf springs and torsion bars are usually replaced only when they break.



Side view of a typical leaf spring installation.



Typical front and rear MacPherson strut component locations. Unlike conventional shock absorbers, strut-type suspensions require that a special compressor tool be used for safe replacement of the shock absorber cartridge.

Coil springs, however, can both break and eventually take a 'set', or fail to fully extend; in either case replacement is required. Various spring spreaders and spacers are available for coil springs, but these are only stopgap measures that will not cure the problem. The only other parts directly related to the springs are the bushings used at the ends of leaf springs. These are usually a steel sleeve with a bonded rubber insert in the center, and the rubber will deteriorate over time causing the spring to rattle on the shackle bolts.

Because a compressed spring will tend to overextend when released, then rebound, or oscillate back-and-forth until all the energy is dissipated, the springs must be damped. If they were not damped, the car would continue to bounce

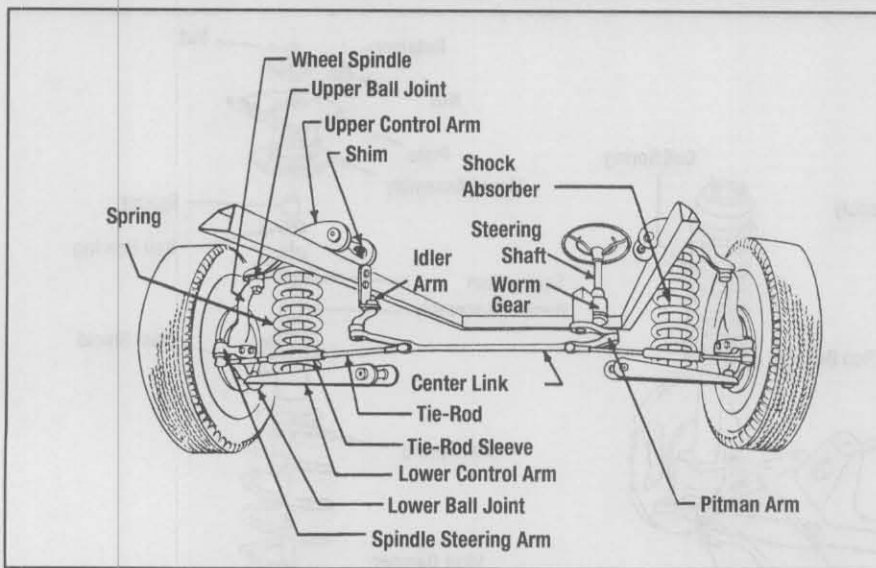
long after hitting a bump. In order to control this a shock absorber, or shock for short, is installed between the frame and axle.

Early cars used lever action friction shock absorbers, which were discs clamped together to control oscillation. These were replaced by hydraulic and gas charged tubular shock absorbers. Tube shocks damp spring oscillation by forcing a plunger through an oil-filled tube. The plunger has carefully-sized holes or orifices, which slow the plunger's travel through the tube to provide the precise amount of damping needed. Most modern shock absorbers vary the damping with spring-loaded valves at the orifices so the shock can react properly to different-sized bumps. One-way valves are used to provide compression damping that is dif-

ferent from rebound damping.

A shock absorber will not raise ride height or improve load-carrying capacity. These are functions of the springs and money spent replacing shocks for these reasons is money wasted, since shocks will only affect ride quality. Unless damaged in an accident or by road hazards, a shock will not fail all at once, but will gradually lose its effectiveness. The customer may not notice anything until the shocks leak or a mounting bushing falls out and causes a noise. As such, the customer may not readily notice the decline in ride quality but will be amazed at the difference after new shocks are installed.

Shock absorber sales offer many opportunities for additional sales and upselling. Most manufacturers offer several grades of shocks



A typical SLA front suspension system with coil springs. The steering linkage can be in front of or behind the theoretical front axle, depending upon space availability.

depending on how the vehicle is to be used but they will not alter suspension capacity or ride height. Heavier shocks can improve a pickup trucks ability to handle a load, and they will certainly last longer, but they will not allow more of a load to be carried. The benefits of premium shocks on a passenger car are longer life and better handling due to superior compression and rebound damping, which will keep the wheels in constant contact with the ground rather than bouncing over a bump.

Front suspension systems can be divided into two basic types: solid axle and independent. The solid axle is no longer used on cars, but is used on some trucks, including many heavy-duty and four-wheel drive applications.

Independent front suspension allows each wheel to travel up and down without affecting the wheel on the other side of the vehicle. A modification of the solid axle was used on Ford light trucks called Twin-I-Beam, which uses two beams, each pivoting from a joint on the opposite side of the truck from the suspended wheel.

One of the more common automotive independent front suspension systems is the double A-arm suspension, sometimes called Short and Long Arm (SLA) suspension. This system uses a pair of horizontal A-shaped members on each side. The feet of the 'A' are attached to the chassis with pivot bushings, allowing the top of each 'A' to swing up and down. A steering knuckle connects to the top of each 'A' with ball joints. These are spherical joints (like those on a hip socket) that allow the A-arms to rise and fall while the steering knuckle swings from side-to-side. The front wheel is mounted on a projection from the steering knuckle called a spindle.

Ball joints and A-arm bushings are the two common wear items on this type of suspension, and just as with U-joints, proper greasing is vital to their longevity. Replacement may require special tools or the use of a press, and a front wheel alignment may be needed after the work is completed. Quality ball joints should have grease fittings and rubber boots rugged enough to stand up to under car

demands, and all the necessary hardware such as locknuts or cotter pins included. Double A-arm front suspension can be sprung by a coil spring on either the top or bottom arm, or a torsion bar may be used. On small older European cars, a transverse leaf spring has been used in place of either the top or bottom arm.

Since the 1970s, MacPherson strut front suspension has become increasingly popular. The MacPherson strut combines a lower lateral link and a trailing link with a vertical strut, which combines spindle and shock absorber functions, as well as a mount for a coil spring. A bearing is located at the top of the strut to allow the whole strut assembly to turn when the car is steered without the coil spring winding up like a clock spring. Since the strut also functions as a shock absorber, it will lose damping ability over time just like any standard tube type shock. The upper bearings are also subject to wear and should be checked or replaced whenever the struts are serviced.

There are many variations in front suspension design. For example, the simple lower lateral link of the MacPherson strut can be replaced by an A-arm for improved fore and aft location. Another variation has the coil spring mounted on the lower A-arm. (The coil spring is usually concentric to and mounted on the strut.)

Rear suspension used to be mostly one of two simple types. The vehicle had either coil or leaf springs; either way, there was a live axle, and depending on the type of springs and the application, some number of radius arms to keep the rear axle in place front to back.

The increasing use of front-wheel drive and the proliferation of independent rear suspension systems have changed that.

With front-wheel drive, there is no need to transmit power to the rear wheels, therefore, the rear suspension can be as simple or as complex as deemed necessary.

The simplest front-wheel drive rear suspension is a dead axle on leaf springs. A dead axle can also be suspended on coil springs and held in position by multiple links. Strut-type suspension can also be used at the rear. This type is similar to the MacPherson strut except usually without steering ability. Fully independent suspension can also be used at the rear, in front-, rear- or all-wheel drive applications. Swing arm suspension is the simplest type. The suspension pivots from the differential in this system, but the camber, or vertical wheel angle, changes drastically with this system and can have quirky handling effects. Semi-trailing arm suspension has a single large A-arm mounted at an angle; this is an improvement over a swing arm system, but is not as good as multi-link rear suspension. Multi-link suspension holds the rear upright in position with an assortment of rods whose geometry controls axle movement. Double A-arm suspension can also be used at the rear, and Chapman struts can be used with rear- or all-wheel drive.

A stabilizer bar can be used at the front and sometimes on the rear of a vehicle. Also called a roll bar, an anti-roll bar, or a sway bar, it is a U-shaped bar, the ends of which are attached to the suspension by links. The crosspiece is firmly attached to the chassis but is allowed to rotate. If both sides of the suspension rise or fall together, the bar has no effect. However, if one side is pressed down, such as when a vehicle leans in a turn, the bar is twisted and resists the rolling or tipping motion. The stabilizer bar, therefore, helps keep the

vehicle level and can be used to tune the vehicle's handling. The end links are usually the weakest point and are prone to breakage, but the rubber bushings where the bar attaches to the frame can also deteriorate and fall out.

Many DIY customers are reluctant to attempt much more than shock absorber replacement, but with the proper tools and the right advice suspension work is not too difficult. More than anything, spring and suspension work involves proper lifting equipment, a good quality spring compressor, and in some cases a press for removing bushings. An air impact wrench can also make the work much easier. As with any under-car repair, safety cannot be overstressed. If your customer is unsure about tools and procedures, take the time to explain them. A compressed coil spring contains a tremendous amount of energy, and can cause injury or death if care is not taken. Coil spring compressors are not that expensive, and the cost of one is probably less than having a garage do the job. Proper lifting and support of the vehicle are also very important to the safe completion of the job.

Steering

A vehicle is steered with the front wheels, although a few four-wheel steering systems have been marketed to make parking and low speed handling easier. The two most common types of steering gearboxes are the recirculating ball worm and nut, and the rack-and-pinion.

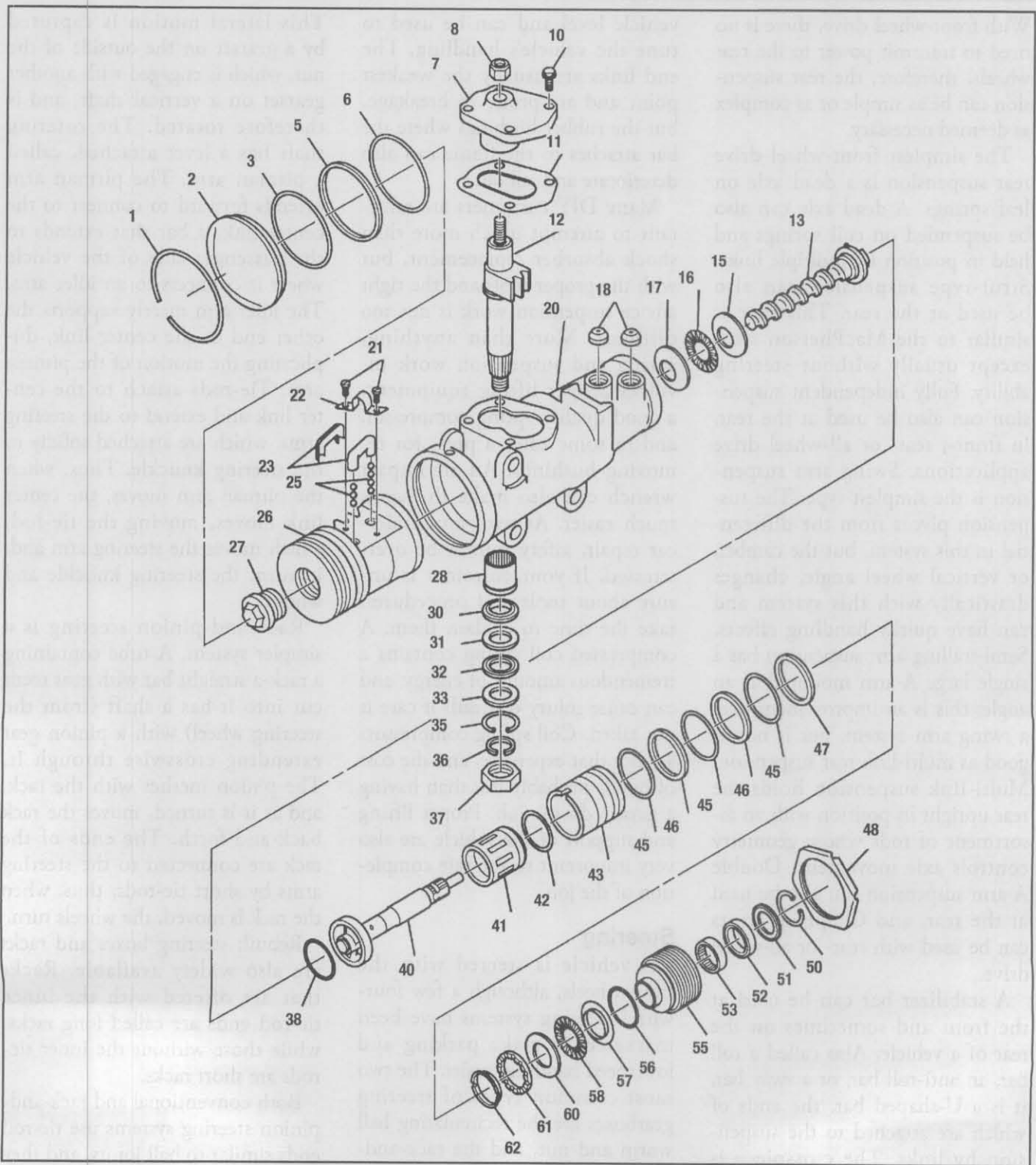
The recirculating ball system, as it is usually called, threads a spiral worm shaft filled with ball bearings through a ball nut, which is grooved internally to correspond to the worm shaft and balls. As the worm shaft is turned, the ball nut moves up and down the shaft.

This lateral motion is captured by a gearset on the outside of the nut, which is engaged with another gearset on a vertical shaft, and is therefore rotated. The rotating shaft has a lever attached, called a pitman arm. The pitman arm extends forward to connect to the center link, a bar that extends to the passenger side of the vehicle where it connects to an idler arm. The idler arm merely supports the other end of the center link, duplicating the motion of the pitman arm. Tie-rods attach to the center link and extend to the steering arms, which are attached solidly to the steering knuckle. Thus, when the pitman arm moves, the center link moves, moving the tie-rod, which moves the steering arm and, in turn, the steering knuckle and wheel.

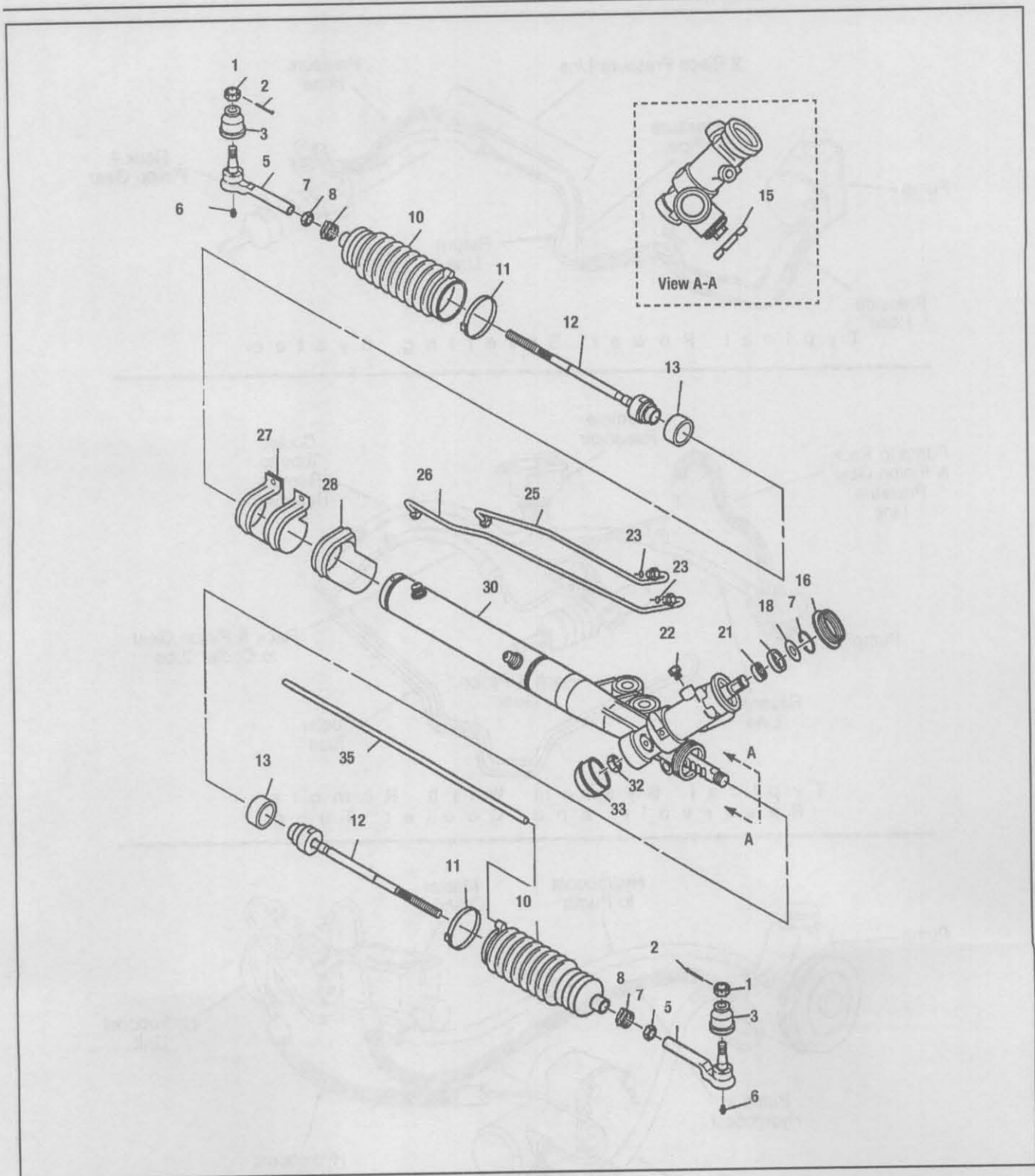
Rack-and-pinion steering is a simpler system. A tube containing a rack—a straight bar with gear teeth cut into it—has a shaft (from the steering wheel) with a pinion gear extending crosswise through it. The pinion meshes with the rack, and as it is turned, moves the rack back-and-forth. The ends of the rack are connected to the steering arms by short tie-rods; thus, when the rack is moved, the wheels turn.

Rebuilt steering boxes and racks are also widely available. Racks that are offered with the inner tie-rod ends are called long racks, while those without the inner tie-rods are short racks.

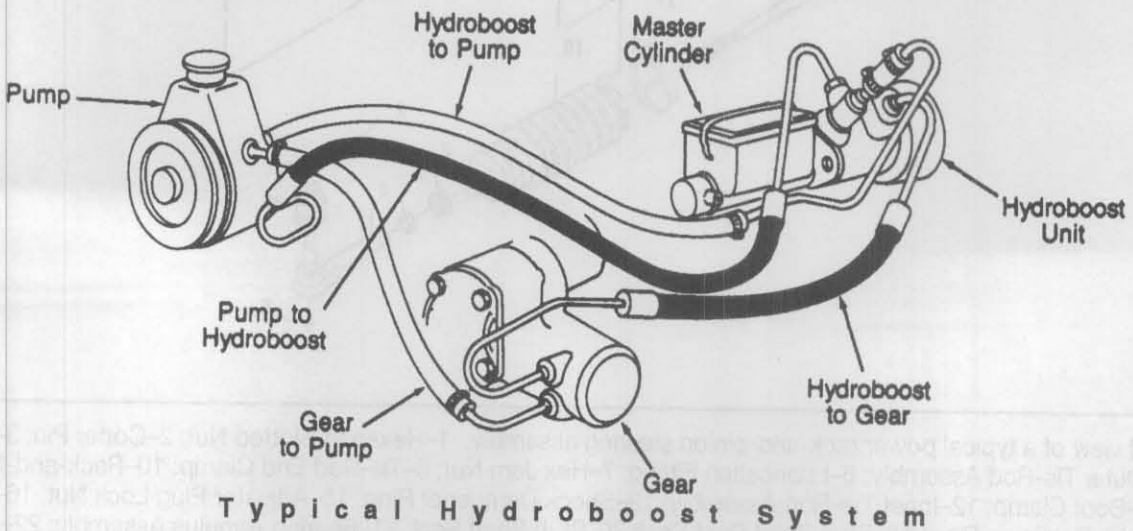
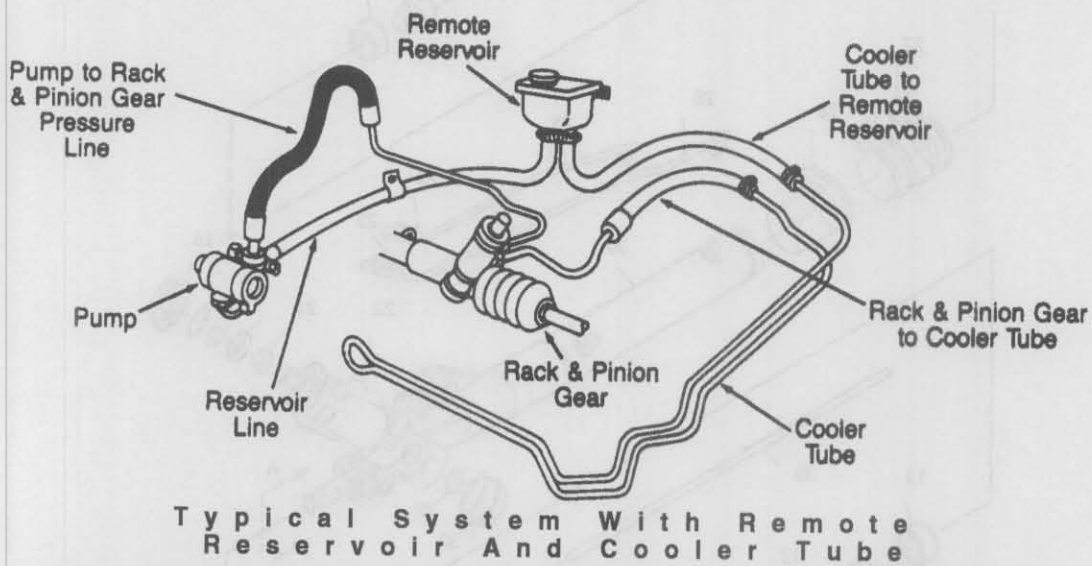
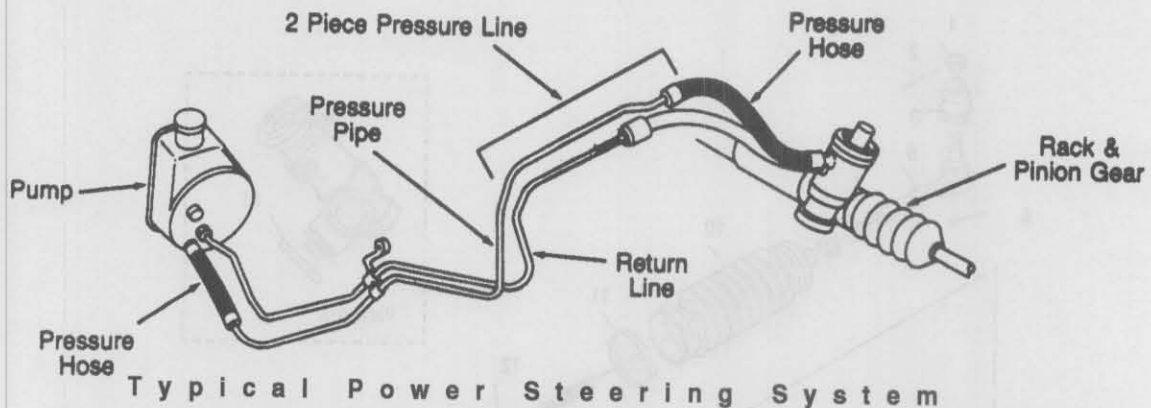
Both conventional and rack-and-pinion steering systems use tie-rod ends similar to ball joints, and they require the same care and maintenance. Proper lubrication and inspection of the sealing boots for tears that allow dirt and water in will greatly improve their service life. Since these types of components wear gradually over time, the customer may not notice anything wrong until the vehicle fails



Exploded view of a recirculating ball steering box. The pitman arm mounts to the splined end of the pitman shaft and transmits movement to the steering linkage. Power steering gear: 1-Retaining Ring; 2-Plug; 3-O-Ring Seal; 5-Teflon Ring; 6-O-Ring Seal; 7-Side Cover; 8-Adjuster Lock Nut; 10-Bolt; 11-Gasket; 12-Pitman Shaft; 13-Worm Shaft; 15-Race; 16-Bearing; 17-Race; 18-Check Valve; 20-Housing; 21-Screw; 22-Clamp; 23-Ball Guide; 25-Balls; 26-Rack Piston; 27-Plug; 28-Bearing; 30-Single Lip Seal; 31-Back-Up Washer; 32-Double Lip Seal; 33-Back-Up Washer; 35-Retaining Ring; 36-Lock Washer; 37-Nut; 38-Seal; 40-Stub Shaft; 41-Valve Spool; 42-Seal; 43-Valve Body; 45-Seal; 46-Ring; 47-Spacer; 48-Adjuster Plug Lock Nut; 50-Retaining Ring; 51-Seal; 52-Seal; 53-Needle Bearing; 55-Adjuster Plug; 56-Seal; 57-Race; 58-Bearing; 60-Race; 61-Spacer; 62-Bearing Retainer. (Courtesy: GM Corp.)



Exploded view of a typical power rack-and-pinion steering assembly. 1-Hexagon Slotted Nut; 2-Cotter Pin; 3-Tie-Rod Seal; 5-Outer Tie-Rod Assembly; 6-Lubrication Fitting; 7-Hex Jam Nut; 8-Tie-Rod End Clamp; 10-Rack-and-Pinion Boot; 11-Boot Clamp; 12-Inner Tie-Rod Assembly; 13-Shock Dampener Ring; 15-Adjuster Plug Lock Nut; 16-Seal Adapter; 17-Retaining Ring; 18-Stub Shaft Dust Seal; 20-Stub Shaft Seal; 21-Bearing Annulus Assembly; 22-O-Ring Plug Assembly; 23-O-Ring Seal; 25-Cylinder (RH) Line Assembly; 26-Cylinder (LH) Line Assembly; 27-Mounting Bracket Assembly; 28-Mounting Grommet; 30-Partial Rack-And-Pinion Gear Assembly; 32-Hex Lock Nut; 33-Dust Cover; 35-Breather Tube. (Courtesy: GM Corp.)



Various types of power steering systems. (Courtesy: Gates Rubber Co.)

a safety inspection or the part actually fails. However, customers complaining of poor handling, uneven tire wear, or wandering steering can often trace the trouble to worn tie-rod ends or ball joints. Repairs may require specialized tools such as a tie-rod separator fork, ball joint press, and in some cases a spring compressor. Depending on the type of suspension or steering work performed, a wheel alignment may also be required when the repairs are completed.

There are several types of power steering, but all use hydraulic pressure created by an engine driven power steering pump to assist the driver in turning the steering wheel. A high-pressure line from the pump delivers fluid to the steering box and a low-pressure return line takes it back to the reservoir. Power assist can be applied to both recirculating ball and rack-and-pinion steering. Power

steering systems can also vary assist with road speed or engine speed. In these systems a solenoid valve is placed between the pump and the steering box or rack. As vehicle speed increases, the valve restricts fluid flow and reduces the amount of assist; the decreased assist increases road feel. At lower speeds or when parking, the valve allows full fluid flow and full assist.

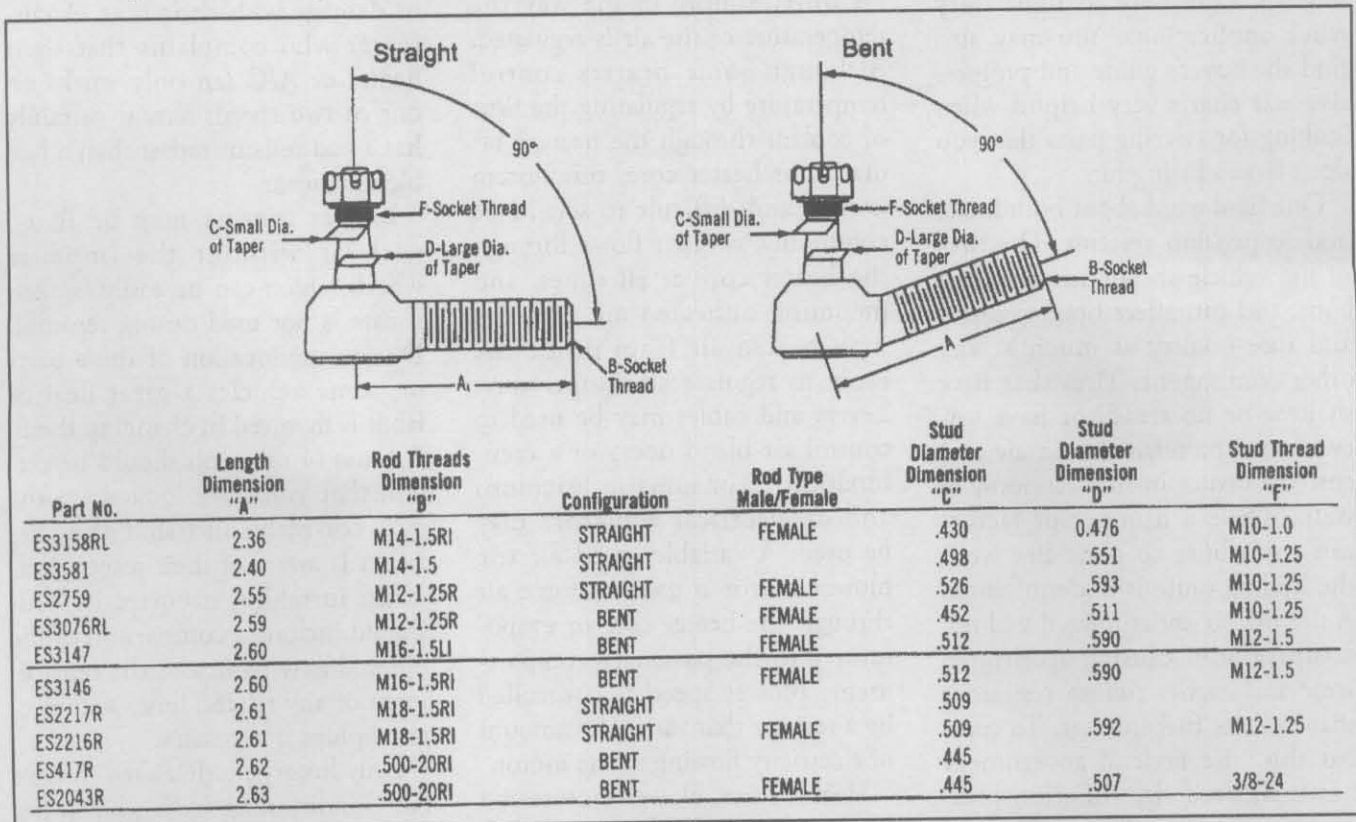
Power steering pumps, boxes, and steering racks are designed so that if a failure occurs in the assist mode the vehicle will still be steerable. Causes for failure are usually due to loss of fluid from leaky hoses or seals in the pump or a worn steering box.

On vehicles without an automatic belt tensioner, over tightening the pump belt can lead to bearing failure. If the pump is run long enough to destroy internal parts of the pump it may also spread metal filings throughout the system and

ruin the box or rack as well. Pumps may be listed in the catalog either with or without the reservoir, and are usually available as rebuilt units. Most pumps come without the pulley however, and the proper puller is required to remove and install it on the new pump. Attempts to change the pulley without the puller usually results in a bent pulley, which may only be available through the OEM dealer.

High-pressure power steering lines should only be replaced with the correct replacement parts; any attempt to use hose clamps and low-pressure line will only cause leaks and loss of steering assist. Return lines may not be under high pressure, but they should only be replaced with hose that is specified for the application. Any customer replacing a pump hose or box/rack will also have to replace the fluid as well.

When looking up tie-rod ends



Progressive size chart from a steering and suspension parts manufacturer's catalog. On applications with no listings, these can be used to obtain the correct part if the customer has an old one to compare with. (Courtesy: Federal Mogul Corp.)

or drag link ends, you may run across left-hand and right-hand versions of the same piece. This may refer to the threads where the tie-rod end screws into the sleeve or rod, or which side of the vehicle it is on. In some cases, you may find that what is listed is incorrect because the rod or link was removed from the vehicle and replaced end-for-end. Many times it is also necessary to replace the threaded sleeve that the tie-rod end screws into, so be sure to suggest this when a customer asks for an end. Be sure also to include any nuts, bolts and cotter pins if not included with the part, and if it is a rack-and-pinion system, ask about the condition of the bellows at the inner tie-rod end. In some instances, it will be much easier to go directly to the paper or electronic buyer's guide catalog and consult a drawing rather than using a computerized word description only lookup, especially in light duty truck applications. You may also find the buyer's guide and progressive size charts very helpful when looking for steering parts that you don't have a listing for.

One final word about both brake and suspension systems. The tires of the vehicle are a critical part of both, and can affect braking safety and ride quality as much as any other component. Tires that have shallow or no tread, or have uneven wear patterns are unsafe and cost the owner in fuel economy as well. While a number of factors can contribute to poor tire wear, the leading cause is underinflation. A tire that is underinflated will not dissipate heat, causing accelerated wear and higher rolling resistance that reduces fuel mileage. To combat this, the Federal government has mandated tire inflation pressure sensors on all vehicles produced beginning in 2007. These are usually mounted inside the tire

on the rim and once set they will illuminate a warning light if a tire falls below a certain percentage of initial inflation. The tire technician working on one of these vehicles will need special tools to detect and reset these sensors whenever tires are rotated or replaced.

HEATING AND AIR CONDITIONING

Gasoline and diesel engines produce a lot of waste heat, and it wasn't very long until someone developed a way to use that waste heat to heat the inside of the vehicle. Though now standard, the automotive heater was an option well into the 1950s.

The typical automotive heater for a water-cooled engine is little more than a second engine coolant radiator. But instead of venting the heat removed from the engine to under the hood, it is directed into the passenger compartment. Heaters differ simply in the way the temperature of the air is regulated. Although some heaters control temperature by regulating the flow of coolant through the heater's radiator, or heater core, this system is slow and difficult to set. More commonly, coolant flows through the heater core at all times, and incoming unheated air is mixed with heated air from inside the cabin to regulate air temperature. Levers and cables may be used to control air blend doors or a combination of pneumatic (vacuum) and/or electrical actuators may be used. A variable speed electric blower motor is used to force air through the heater core or evaporator into the passenger compartment. Blower speed is controlled by a resistor that varies the amount of electricity flowing to the motor.

Heater cores, blower motors and resistors are the most common aftermarket heater component sales. Heater cores can leak or become

plugged by dirty coolant. Blower motors can suffer from wear on the armature bushings, just as with any electrical motor, which causes them to draw more current to operate at speed. As wear occurs the motor will slow down, and after enough wear occurs the motor will fail completely and can cause overheating of the wiring or blown fuses. Another common cause of blower motor failure is foreign objects jamming the wheel, which can also lead to wiring failure or blown fuses. Variable speed resistors are little more than different size coils of wire that only allow a set amount of current to flow through each coil. As the current passes through them the coils can get very hot. Because of this they are usually placed somewhere in the heater duct work where they get a flow of cooling air over them, and also to isolate them from other components that they might burn or damage with their heat. A customer who complains that their heater or A/C fan only works on one or two speeds almost certainly has a bad resistor rather than a bad blower motor.

Blower motors may be listed with or without the impeller wheel, which can be easily broken if care is not used during removal. Due to the location of these parts on some vehicles a great deal of labor is involved in changing them. Because of this, you should be certain that you have looked up the part correctly, and that the customer is aware of their responsibility in installing it correctly. This should include a comparison of the old and new parts and the replacement of any related hoses and electrical plugs if necessary.

Only luxury models used to have Air Conditioning (A/C), but it has now become standard or optional on most vehicles. Air conditioning works on the principle that a gas

will heat up when it is compressed, and cool when it expands. The air conditioner works by compressing an air conditioning gas (refrigerant) in a compressor. The heated gas is then passed through a condenser and cooled to the point that the gas changes to a liquid. The liquid refrigerant then leaves the condenser and goes to the refrigerant metering device. Depending on the type of system, either a Thermostatic Expansion Valve (TXV) or an orifice tube meters refrigerant into the evaporator, where it changes back to a gas. Air conditioning works by blowing air across the evaporator, through which the cooled gas travels. Moisture in the air passing over the evaporator condenses, is drained off, and is frequently seen running out from under air-conditioned cars when they are stopped.

A/C systems don't require any type of preventive maintenance aside from compressor drive belt inspection and replacement. They will, however, lose refrigerant over time due to leaky or porous hoses, fittings, and compressor seals. An A/C system that blows cool air but not sufficiently cold enough to cool the vehicle interior is low on refrigerant. When this happens it is often possible to add refrigerant with a simple recharge kit. If enough has been lost however, as indicated by only warm air coming from the ducts, or the compressor not engaging, it is advisable to have the system opened, the compressor oil level checked, evacuate any air in the system and make sure it holds vacuum. If the system won't hold a vacuum there is a leak somewhere and any fresh refrigerant put in will quickly leak out. It's also advisable in climates where the A/C is not used for long periods to make a habit of turning it on once a month or so to keep the compressor oil circulated and

the system lubricated. Compressor failure can almost always be traced to a lack of lubricant, and when this happens it can spread contaminants throughout the system that can cause other expensive damage beyond just compressor replacement.

Compressor clutch bearings are also a common trouble spot. Since the clutch pulley turns whenever the engine is running these bearings are subject to wear all the time. Hoses and fittings are all subject to high under hood temperatures, which can take their toll on rubber and neoprene O-rings. External forces such as accident damage and corrosion from dirt and road salt can cause condensers to leak as well.

The refrigerant that was used for years to air-condition cars is a chlorofluorocarbon (CFC) called Freon®, or R12. Because it is suspected of damaging the upper atmosphere, R12 has been phased out in the U.S. according to federal decree. All vehicles made since 1996 use a refrigerant called R134a. R134a, which contains no chlorine, is thought to be harmless to the atmosphere, but is less efficient than R12. To compensate for this fact, new air conditioning systems have been redesigned, using larger condensers and higher-volume fans and receiver-driers. Remember, the principles for the refrigerants may be the same, but the parts and chemicals are not. So, making any changes to these systems will affect the way the system cools, and can even cause damage. Follow your catalog's advice as well as federal guidelines.

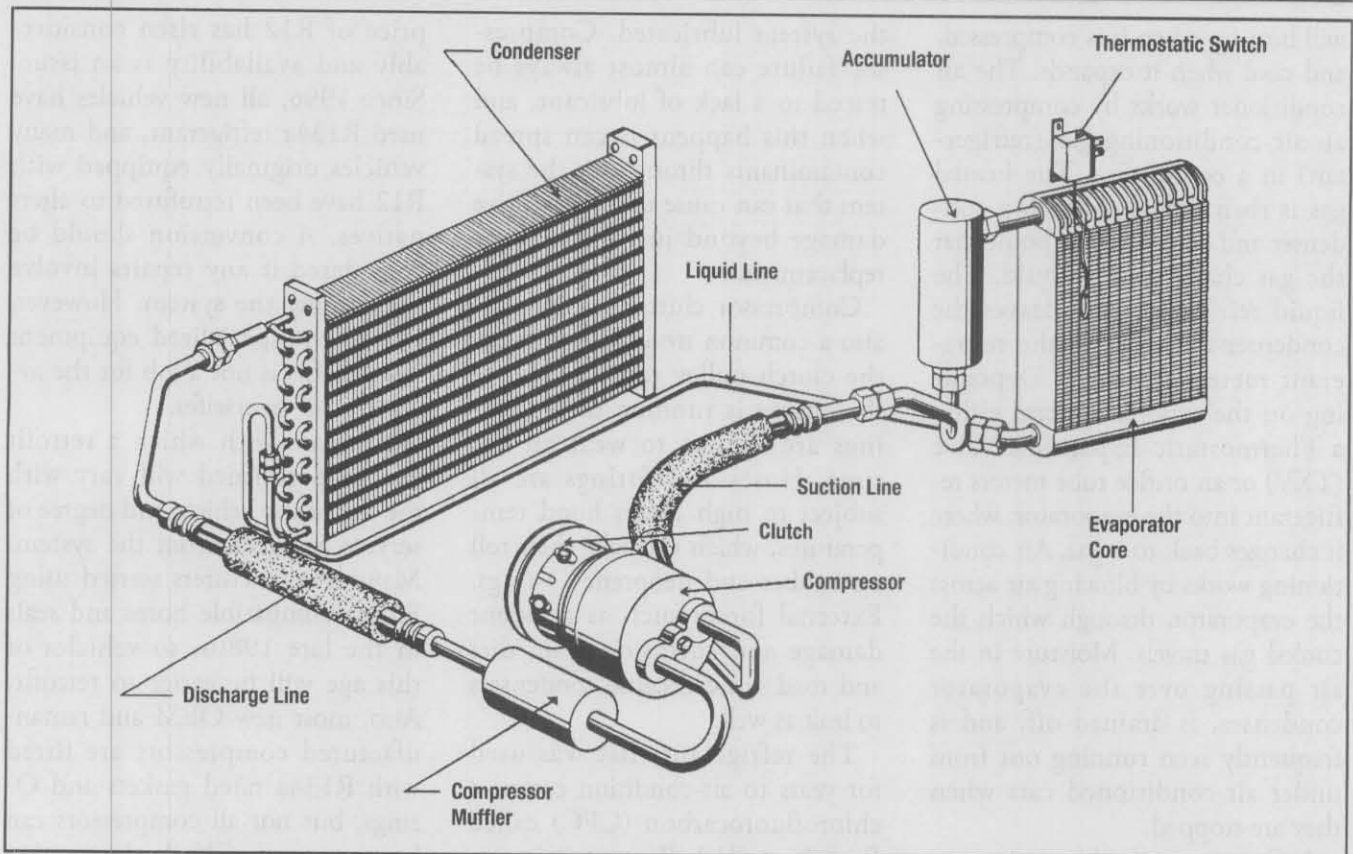
R134a Conversion

Since 1990, the U.S. government, along with other industrialized nations, has been working to phase out the use of R12 as a refrigerant gas. Because of this, the

price of R12 has risen considerably and availability is an issue. Since 1996, all new vehicles have used R134a refrigerant, and many vehicles originally equipped with R12 have been retrofitted to alternatives. A conversion should be considered if any repairs involve discharging the system. However, due to the specialized equipment needed this is not a job for the average do-it-yourselfer.

The ease with which a retrofit can be performed will vary with the age of the vehicle and degree of service expected from the system. Many manufacturers started using R134a compatible hoses and seals in the late 1980s, so vehicles of this age will be easier to retrofit. Also, most new OEM and remanufactured compressors are fitted with R134a rated gaskets and O-rings, but not all compressors can be converted. Check the catalog listings before attempting to sell a unit you know will be used in a retrofit. Older, non-barrier type hoses, can be used if they are in good condition and do not leak. The interior of these hoses will have a coating produced by the R12 and mineral oil lubricant, which will help prevent R134a from seeping through. Condenser capacity should be checked and if it is inadequate, the condenser should be replaced. Check your catalog listings or a retrofit manual if you have any doubts.

A basic conversion consists of removing the old R12, flushing the system of any mineral oil lubricant, removing and draining or replacing the receiver-drier/accumulator, installing a high-pressure cut-out switch if none is present, and permanently replacing the charging hose fittings. While the system is drained, all repairs should be performed and all components checked for operation and compatibility with R134a. After this



A typical automotive air conditioning system. (Courtesy: Everco Corp.)

is done, the proper lubricating oil should be added, the system evacuated of air and charged to 80% capacity with R134a and a system check performed. Finally, a tag must be affixed under the hood stating the type of refrigerant used.

This is a fairly simplified explanation and some technicians may get far more involved than this. The most important thing to remember however, is that all of the system components must be in good working order, and this is an excellent opportunity for added sales. Most compressor manufacturers require that the receiver-drier or orifice tube be replaced along with the compressor to maintain warranty. Be sure to remind the customer that once the system is charged, a problem may require evacuating the refrigerant again, so it pays to do it right the first time.

ELECTRICAL/ ELECTRONIC SYSTEMS

This section will deal with vehicle electrical systems, exclusive of the starting, charging, and storage systems. Since just about all accessory items and systems are electrically operated, this can cover quite a lot but the basic principles are all the same.

Almost all vehicles produced today have a 12-volt negative ground DC (Direct Current) electrical system. AC (Alternating Current) produced by the alternator is rectified to DC and regulated to the proper voltage to keep the battery charged. Accessory items such as lights, blowers, and even ignition and injection systems all draw power from the battery by way of the fuse panel and wiring harness.

Power flows from the positive side of the battery through the accessory item and then to ground to

complete the circuit. An interruption of the circuit between the accessory and ground will cause the item to not function but should cause no other damage. If the circuit is run to ground or short circuited before the accessory, or if the item starts to draw too much amperage due to a malfunction; fire or other serious damage will result if the circuit is not protected. Fuses, fusible links and circuit breakers are all used for this purpose. In the event of a short or overload, the fuse—which consists of a thin metal strip encased in either a glass tube or plastic holder—will melt at a predetermined amperage rating and open the circuit so no current can flow.

Fuses, fusible links and circuit breakers all perform the same function but in a different way. A fusible link is a special wire that acts as a fuse. The fusible link will

respond to electrical overload by first burning its hypalon insulation. Continued overload will result in the fusible link burning out and breaking the circuit. A circuit breaker combines a bi-metallic strip and a set of contact points. Excessive current will cause the strip to heat up and bend due to the different expansion rates of the two metals, pulling the contact points apart. When the strip cools, the points make contact again and the accessory will operate.

Most vehicles have a fuse panel located within the passenger compartment. It contains all of the accessory fuses and a directory of what each fuse controls and its amperage rating. Some vehicles may have another panel located in the engine compartment containing a master fuse and other fuses related to engine or four-wheel drive applications. Circuit breakers are most often found in headlights and other high amperage draw situations, and are used almost exclusively in place of fuses in commercial trucks and buses.

When a fuse blows, it is important to find out why and correct the problem or it will just continue to blow when a new one is installed. You should never instruct a customer to use a higher amperage fuse or circuit breaker in place of a lower one to cure a recurring blown fuse. To do so will place them at risk of an electrical fire, which you could be blamed for.

Wire used throughout the electrical system is multi-stranded, vinyl insulated, and available in many different color codes and gauges. The color coding makes it easier to trace a wire through its circuit; if everything was wired in one color it would be almost impossible to do any wire harness repairs. Wire gauge refers to the thickness of the conductive core, the higher the number the thinner

the wire. To put it in perspective, a 14 gauge wire, which is a common size used for exterior lighting, is 0.064-in. in diameter while a 1 gauge wire, typical of a battery cable, measures 0.2893-in. The larger a wire's diameter the more current carrying capacity it has, just as a large water hose can flow more water in a given amount of time than a smaller one. Using the example of a hose, if you tried to force the same amount of water through both, the pressure or resistance in the smaller hose would build up until it burst. Trying to substitute a smaller wire in place of a larger one will cause higher resistance in the circuit, which can cause the electrical device being powered to fail and the wire insulation to melt. If the excessive load is not stopped by a fuse or circuit breaker, it will eventually cause the wire to melt and possibly start a fire.

Rolls of replacement wire and connectors should always be matched to the gauge of the existing harness; never substitute a smaller sized wire. If a customer is wiring in an accessory circuit for additional lighting or other accessory, make certain the wire is large enough and that any switches used are rated for the amperage the accessory will draw.

It may be necessary to use a relay in some circuits if the accessory has a high amperage draw, such as with fog lights. A relay is a switching device with an electromagnetic coil that is activated by the switch on the dashboard used to turn on the accessory. When the dash switch is on, it activates the electromagnet, which closes a set of contacts within the relay. These contacts then activate the device being powered. Using a relay allows the wiring to the dash switches to be much smaller than the wires necessary to power the device. A good

example of this is a starter motor relay. If it were wired directly to the key switch it would be necessary to run heavy 1 gauge wire into the steering column and the switch itself would have to be much larger to handle the current. Using a relay, 16 gauge wire can be used to activate the starter and a switch rated for as little as 10 amps used in the column.

Wire ends and connectors are also matched to wire gauge and color coded to show which gauge they fit. The most common sizes used are red, for 18-22 gauge, blue for 14-16 gauge, and yellow for 12-10 gauge. Various types of ends and butt connectors are available, insulated and non insulated, crimp on and solder on, as well as with heat shrink sealing insulation.

Light bulbs are found throughout the interior and exterior of a vehicle. Headlights have evolved from the old incandescent bulb set in a polished metal bowl to sealed beam units in both round and rectangular shapes as well as halogen sealed beams. Most vehicles produced since the early 1990s have been made with an encapsulated halogen headlight bulb installed in a housing similar to the type used in very early vehicles, with several major differences. Aside from the fact that the halogen bulb produces a much brighter and whiter light, the materials used for the housings are molded plastic rather than metal. This allows the vehicle designers to make them lighter and more aerodynamic for better vehicle fuel efficiency, and it eliminates the problem of the reflectorized surface becoming tarnished or rusted and flaking off. The lenses on these however can yellow over time and make the lights dimmer so special polishing materials are available to clean them.

All light bulbs will eventually burn out because the filament in-

side the bulb, which produces the light, deteriorates with use and eventually breaks. This presents opportunities for direct replacement sales as well as upgraded and add-on sales. Halogen replacement bulbs are available for just about every application where they were not OEM fitted and should be sold in pairs if the customer is upgrading. Encapsulated bulbs are available in 'bright white' or 'laser light' versions, which use a xenon gas to produce a brighter light. Encapsulated bulbs are generally easier to change than a sealed beam because no tools are required; simply unplug a wire harness and twist the bulb or retainer ring out, then remove the bulb. Care should be taken to avoid touching the glass surface of the bulb, however. Halogen lights burn hotter than a regular incandescent light and if oil from your skin gets onto the bulb surface it can boil and cause the glass to shatter at that point.

High Intensity Discharge (HID) headlights are starting to appear in some luxury and exotic sports car applications; these are the ones that appear blue as they approach you. They work by passing an electric current through a gas, which causes it to produce light, similar to a fluorescent lamp. HID lights require a transformer as well as some specialized wiring, and while aftermarket kits are available they are relatively expensive. Retrofitting these may also require altering existing headlight switch wiring if both the high and low beams do not stay on when the dimmer switch is in the high position. The HID transformer may need a few seconds to warm up when switched on, and if they go out when the dimmer switch is moved a lag will occur when they are switched back on.

There are a huge number of different lights used on vehi-

cles today and cataloging them would be a problem if there were no standards. All bulb manufacturers use the same designations for the same bulbs, so an 1157 manufactured by Wagner is completely interchangeable with an 1157 made by Osram or any other manufacturer. Problems can occur however, if bulbs with the same base type are substituted where they do not belong due to different amperage draws. Use of the wrong bulb can affect brightness as well as operation of bulb sensors and other computer controlled functions. The vehicle OEMs will also often list bulbs by trade number and part number as well. Headlights and other bulbs are not something most people think about until they burn out, often leaving them in the dark and subject to being stopped by law enforcement. Point-of-sale displays of emergency fuse and bulb assortments can help both the customer and your sales.

Other items found in the vehicle's electrical system include heater and A/C blower motors, wiper motors, lock solenoids, window motors and just about anything that requires motion to operate. These are all application specific, but add on sales can be made on parts such as wire and wire connectors, dielectric grease, switches and fuse holders for accessory circuit additions, and test lights and meters.

BATTERY, CHARGING AND STARTING SYSTEMS

Although an automobile runs on gasoline or diesel fuel, there are a number of onboard systems that require electricity. Unless the vehicle is to travel no farther than the length of an electrical extension cord (or for the distance its battery will last), it must have an onboard electrical plant.

Unlike household appliances, which use AC (Alternating Current), automotive systems operate on DC (Direct Current). On older vehicles, a generator supplied direct current for the vehicle's electrical system. A generator uses current from the battery to create a magnetic field in a stator; rotating a wire loop through the magnetic field will cause current to flow. The generator uses a collection of loops, called an armature, within the field to create a constant flow of electricity. Carbon brushes contact the commutator at the end of the armature to complete the electrical circuit.

An alternator works in a similar way, but produces alternating current that must be rectified (changed) to DC before it can be used in the vehicle. Because an alternator produces more amperage, even at low rpm, it has replaced the DC generator on the accessory-laden modern car. While the DC generator spins the armature (output) coils inside the stationary field coils, the alternator spins the field coil inside the stationary stator windings (output). A rectifier, also called a diode bridge, converts the current from AC to DC by allowing current to flow in one direction only from the alternator.

A voltage regulator is required with either an alternator or generator, and can be either the electromechanical or transistor type. The latter can be incorporated into the alternator body. Although this is more space-efficient (an important consideration under the hood of modern vehicles), it also often means that should either the generator function or the voltage regulation function become defective, the entire unit must be replaced. The regulator performs two functions, it regulates the amount of voltage being produced by the generator or alternator, and it also

keeps voltage from back flowing from the battery when the vehicle is not running.

Alternators have been standard equipment on almost every car, truck and piece of motorized machinery since the early 1960s, but there are still people who don't know how to properly test them. It was common practice with generator equipped vehicles to disconnect the battery ground cable to see if the generator was working; if the vehicle kept running it was working. Doing this with an alternator equipped vehicle can cause serious problems. Some alternators require an external exciter current to work. Disconnecting the battery causes this current to stop so it is not a valid test. Also, if the cable is disconnected and reconnected while the vehicle is running, it can cause a voltage spike that can destroy both the alternator and voltage sensitive components such as the ECM/PCM. The only proper way to test an alternator is by measuring voltage at the battery with the engine running (it should be between 13 and 14 volts on a 12-volt system) or on a bench tester. Failure to follow proper testing and installation procedures, or removing the housing bolts to spin the rear half to change connector position, may void any warranty and possibly cause expensive damage to the vehicle.

It's important to remember that alternators are not battery chargers, they are battery maintainers. If a customer has had an alternator fail, chances are that the battery has been run down as well. If the battery is not checked and recharged, the excessive load placed on the new alternator as it tries to recharge the battery may cause it to fail quickly. Some rebuilders have gone as far as putting a sensor in the unit that checks battery voltage in an effort to reduce customer in-

duced failures. It will not allow the unit to charge if battery voltage is insufficient.

The starter is a small electric motor that draws a large amount of amperage for a short period of time to crank the engine. A starter must do two things: It must first engage its pinion gear with the ring gear around the outside of the flywheel, then it must turn the flywheel/crankshaft fast enough to start the engine. The Bendix-type, self-engaging starter drive uses the starter motor rotation to move the pinion from its recessed position away from the ring gear. When the pinion hits a stop, it is engaged with the ring gear and the spinning starter motor turns the pinion. As the engine starts and spins the ring gear faster than the pinion, the pinion is forced back and it disengages from the ring gear.

Another type of starter uses a starter mounted solenoid switch (a push-pull magnet) to engage the pinion, sliding it forward on a spiral-splined shaft. In addition to moving the pinion into mesh, the solenoid also closes a set of contacts between the battery and the motor, causing the starter motor to spin. An overrunning clutch keeps the pinion from overspeeding the starter motor when the engine starts. Once the engine has started, the driver releases the key, which deactivates the solenoid, withdrawing the pinion and releasing the starter contact.

The two types described above are direct drive types, the drive is mounted directly on the armature shaft, but there are also gear reduction type starters. As the name implies, the starter motor is geared to a reduction unit that converts higher motor RPM to higher torque for spinning the engine over. They are generally more compact than a direct drive type and can produce more cranking power

while drawing less amperage from the battery. Chrysler in particular used this type for years, and a number of foreign manufacturers use them as well. In addition, some Ford and GM pickups can be retrofitted with gear reduction types in place of direct drive.

Starter problems generally fall into two categories, failure to crank and bad pinion engagement. Failure to crank can be caused by poor connections or a weak battery, as well as excessive amperage draw by the starter itself due to worn armature bushings. Pinion engagement is adjustable on some GM built vehicles by means of shims used to move the starter in or out in relation to the ring gear. The problem may also lie in the condition of the ring gear, and this may be detectable by looking at the condition of the old starter's drive pinion. If the gear shows signs of excessive wear or chipped and broken teeth, then the ring gear should be suspect as well. Installing a new starter in a vehicle with a bad ring gear will almost certainly be cause for a come-back and someone looking for a free replacement. If the problem exists only when the engine is hot, it is most likely a starter malfunction or possibly ignition timing. Whatever the cause, just as with an alternator, be wary of the customer who gets several 'defective' units in a row. Some people, and this includes a few professional installers, may install a starter or alternator without really taking the time to diagnose the problem.

The most common battery in automotive use today is the lead/acid battery. This is a series of lead plates set into a sealed case, which is flooded with a sulfuric acid electrolyte solution. The resulting chemical reaction between the lead and acid produces electricity. A by-product of this reaction is sulfation of the plates. This sulfation builds

inside the case to the point that the plates are no longer isolated from each other, they are bridged, and that cell or grouping of plates will no longer function. In a standard 12-volt battery there are 6 cells that produce 2 volts each, so if even one cell is bad battery output will suffer greatly.

Though most batteries in use today are 12-volt, they are available in different physical sizes and terminal configurations as well as types. The standard type battery most people are familiar with is called a wet cell or flooded battery. These may be either maintenance free, with no removable caps, or serviceable types. AGM, or Absorbed Glass Mat batteries are basically flooded batteries but the lead plates have a glass mat between them that absorbs the acid. This helps improve battery efficiency as well as lessen the chance of hydrogen explosion and corrosion from charging. They also have the added benefit of not spilling their acid out vent holes if they are tipped over. This is a major consideration on applications such as motorcycle and power sport equipment such as ATV's. Many deep cycle or marine batteries are AGM types as well. Deep cycle batteries have more robust plates and are designed to be discharged and recharged many times, such as when used in RV's or boat trolling motors. Finally we have the GEL CELL battery, sometimes confused with the AGM type. These are not wet cell batteries, the electrolyte has a silica additive that causes it to harden or gel up. They are used as deep cycle batteries only in applications such as electric powered wheel chairs, and are very sensitive to charging voltages.

Batteries also come with different cranking amp ratings, which is a measure of their energy content. Higher amp-hour ratings will

give more reserve for difficult starting and will also last longer than an equivalent battery with a lower rating. Batteries can be identified either by measurements or by a BCI group number stamped into the case by the positive terminal. Quality batteries with high cold cranking and reserve amps are an easy upsell item, especially in cold climates and for diesel engine vehicles.

Since all batteries will eventually fail, even with the best of maintenance, the warranties offered on them are usually different than that of hard replacement parts. A manufacturer may offer a full lifetime warranty on a ball joint, which can last the life of the vehicle with proper care, but this doesn't happen with a battery. They are most often sold with a guaranty period of so many months (e.g., 36, 60 or 72) and replacement cost based on a pro rate or sliding scale. For example, if a battery has a 65 month warranty with 24 month free replacement, and it fails within the first 15 months of service, the manufacturer will replace it for free. If however it fails in 26 months of service the customer will be charged a fee for each month it was in service, not just for the 2 months it was out of full warranty. Using this example, if a customer buys a battery for \$60.00 with a monthly pro rate fee of \$1.00, and it fails in 26 months, you must bill the customer \$26.00 for the replacement battery. It is also common practice to consider the replacement battery as being 26 months old when installed, the warranty does not start all over again after a replacement unit has been given out.

Battery testing falls into three basic areas: check for physical condition, check for voltage, and check for amperage. When looking for the cause of a battery failure the

first thing to look at is the condition of the case. Holes obviously indicate outside abuse such as improper hold-downs or accident damage; the same goes for loose or damaged terminals. Melted terminals are an indication that the battery was installed wrong. If you are in a cold climate and the battery has bulged out sides it's a good indication that it froze at some point. A fully charged battery will not freeze, but as they lose charge the acid is absorbed by the plates leaving behind the water that it's mixed with. If the solution is weak enough to freeze it can warp the lead plates and short them out.

If the battery has removable caps, check the electrolyte (acid) level. Low levels, especially in the cells closest to the terminals, can indicate overcharging or lack of maintenance. If you must add fluid its best to use distilled water as the minerals and/or chemicals in tap water might cause problems. If you have a battery hydrometer you can check the specific gravity of the acid in each cell. The electrolyte is a mixture of water and acid, and since the acid weighs more than water the specific gravity will be higher than that of plain water. The specific gravity of water, for reference, is 1.000. A fully charged battery should read 1.265 to 1.270, with all cells having the same reading plus or minus .05. If any one cell is off more than this that cell is probably sulfated and the battery is no good.

Next check for voltage with a voltmeter. A fully charged 12-volt battery should read at least 12.8 volts. If the specific gravity readings are low all the way across and the voltage reading is low the battery must be charged before a proper load test can be done. Load testing is done with a voltage meter that has a resistor coil built on to it. When the meter is hooked up

it will show initial battery voltage. Battery current is passed through the resistor by pressing a switch on the meter, and the strength of the battery gauged by the voltage drop. Most testers have a needle that will indicate good, weak, or bad/replace. This resistor will get very hot in operation because full battery amperage is being passed through it, so care should be taken. Digital testers are also available. These are hooked to the battery and the Cold Cranking Amp (CCA) rating is entered into the tester. When the test button is pushed it will measure voltage and available CCA as well as tell if any cells are bad. These testers can be much more accurate than an analog load tester, but it comes at a price; they are usually much more expensive than the old style load tester.

Your customer may wonder why a fairly new battery can fail and how they can prevent it in vehicles or equipment that only see occasional or seasonal use. All batteries, no matter how good, will loose charge when they sit, especially if there is any parasitic drain on them from radios or other onboard equipment. In order to prevent this several steps can be taken. The first is to install a battery cutout switch or just disconnect the ground cable if the vehicle will be stored for any length of time. This will stop any parasitic drain but the battery will still need to be charged occasionally. One way to do this is to hook up a small 1 or 2 amp trickle charger and turn it on and off at regular intervals. If the charger were left on all the time it would eventually boil the water out and possibly ruin the battery. Another method is to connect a battery maintainer and leave it on all the time. These chargers have a sensor built in that signals when the battery has dropped below a certain level of charge and will automati-

cally turn the charger on. These can be safely left hooked up for very long periods of time without causing battery damage. This type of charger is ideal for equipment such as emergency generators as well. The customer who stores a vehicle over the winter and thinks that starting it every few weeks will keep the battery charged will be disappointed. The amount of current it takes to start the vehicle can take several hours to be replaced by the alternator and if the vehicle is not run long enough, instead of helping the battery, it will result in a net loss of battery voltage.

It should be noted that all of these procedures apply only to the batteries used in conventional internal combustion engines. Hybrids and electric vehicles use a completely different type of battery than those used to start your vehicle. They are larger, heavier, and use different technology to store and produce the power needed to move a vehicle, and the cost is much higher than conventional lead/acid batteries. As of this writing there is very little available through the aftermarket for these vehicles.

Starter and alternator sales will most likely make up the bulk of your electrical system sales. The loads placed on modern electrical systems are increasing all the time, while physical space decreases and underhood temperatures rise. This can lead to alternator failure in a short time if the rest of the charging system is neglected. Battery cables and starter connections should all be checked and repaired if needed, and the condition of the battery itself should be checked. Corrosion that builds up on terminals and connections acts as an insulator and decreases the amount of current it can pass. Just as with the customer who complains about OEM brakes outlasting aftermar-

ket parts, but fails to take into account that when the OEM linings were new so was everything else, so too should you consider electrical systems. Over time every connection can corrode, and every component can wear to the point of developing higher resistance and amperage draw. This means that the overall condition of the entire charging/starting system must be taken into account when diagnosing problems.

Most remanufacturers bench test their units before shipping them, but occasionally you will get a bad one. However, beware of the customer who claims to have gotten two bad units in a row, or who has one fail within days of being installed. This is often a sign that there is something else wrong and the end result is a non-functioning starter or alternator. If your facility has a bench tester, offer to test it while the customer watches, and explain what else could be causing his problem. Some rebuilders do offer several grades of product, and some offer brand new units, so the opportunity to upsell may be possible.

Most stores have a no return policy on electrical items and will only replace a unit, not refund the purchase price. Check with your manager or supervisor, and if this is the case, be sure to explain this policy to any customer who is unsure of his real problem. This will stop any hard feelings or misunderstandings before they start.

MISCELLANEOUS

Hoses, Tubing And Fittings

Stock-in-trade for the automotive supply store is a variety of hoses, tubing and fittings. Air (often at less than atmospheric pressure) and a variety of fluids must be transferred from one part of the vehicle to another, but be-

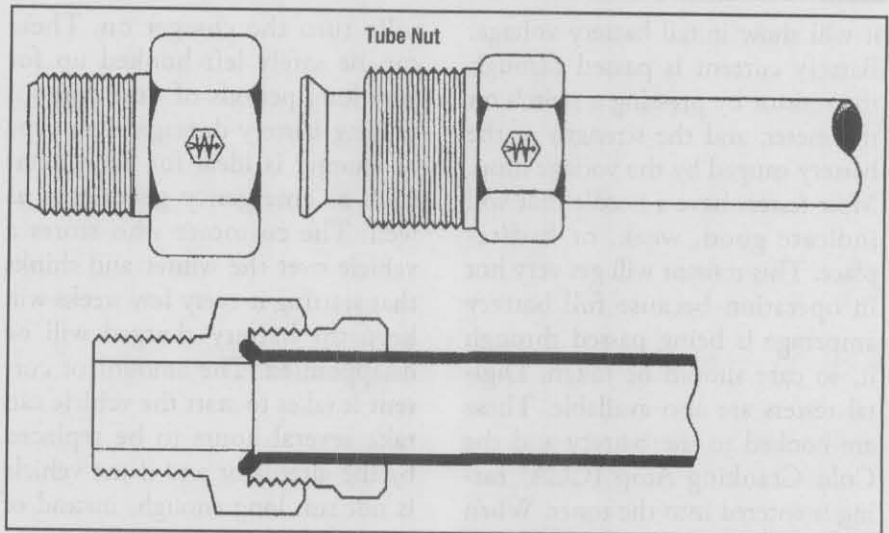
cause volume, pressure and material to be moved all vary, so do the tubes and hoses. It is important to understand the descriptions of various fittings and hoses used for air conditioning, brakes, cooling systems, fuel systems, power steering and other systems.

When measuring hose, tubing or pipe you have to know what to measure if you want to get the correct size. Hose and pipe are measured by inside diameter, while tubing is measured on the outside diameter. Fittings and connectors always refer to the size of hose, tube or pipe that they are used with. For example a 1/4-in. compression fitting for tubing will have a 1/4-in. hole through the nut, not 1/4-in. diameter threads. A connector will refer to both sizes of the materials being connected, such as a 3/8-in. male pipe thread to 5/16-in. rubber hose.

TUBING

Rigid tubing can be made of copper, steel, stainless steel, aluminum or plastic. Copper is soft and easy to bend, and can be used for carburetor gas lines, vacuum lines, lubrication lines, and other low-pressure applications. It should never be used in high-pressure applications such as brake or power steering lines, or fuel lines on fuel injected engines.

Steel must be protected from corrosion (except stainless steel, which resists corrosion), but otherwise it is sufficiently strong for all automotive applications. Common applications are brake and fuel lines, and power steering and transmission cooler lines. Unless you are dealing with pre-bent tubing, a few special tools may be needed. Most of the tubing used in automotive applications is rather soft and easy to bend but it will also kink if the bends are not formed properly. Tubing bend-



Inverted flare commonly found on brake line fittings.
(Courtesy: Boston Weatherhead/Dana Corp.)

ers are available that allow smooth bends to be made without flattening or kinking, and a tubing cutter will make a clean cut without crushing or distorting the end.

Plastic tubing is not as flexible as rubber hose, but is not subject to the same types of degradation. Unless designed for it, it cannot handle the high pressures or heat of brake and cooling system use. It may, however, be used for fuel, vacuum and some lubrication applications. It is also used extensively in air brake applications where system working pressure is normally at 150 psi.

FITTINGS AND CONNECTORS

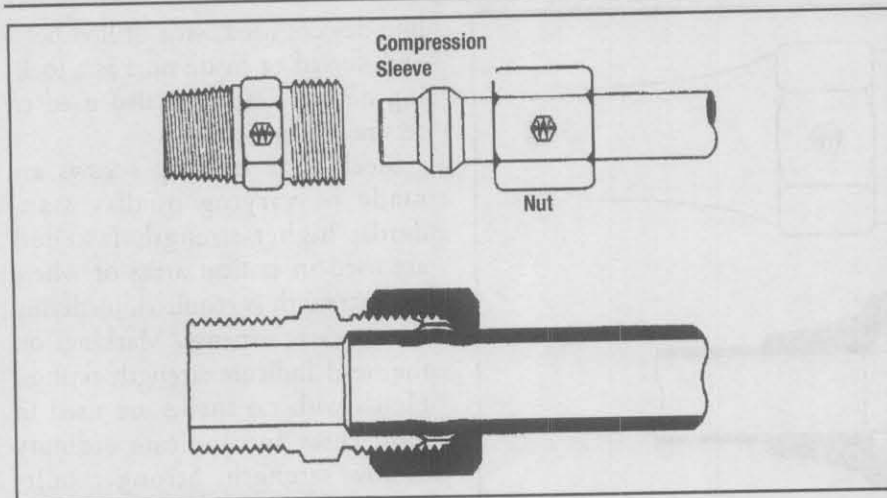
Tubing must be attached with fittings. There are four common types of fittings found in automotive use: flare, compression, barbed and pipe. Flare fittings can be used on any type of tubing that can be flared, such as steel or copper. High-pressure applications, such as brake or power steering lines, require flared fittings. A flaring tool is used to put a cone-shaped outward angle, or flare, on the tube end. A nut with a recess shaped to the flare is slid onto the tube, and then the tube is flared. The flare

nut is then threaded into a fitting or port, which has an external flare that matches the internal flare on the tube, and as the nut is tightened, it forms a leak-proof seal.

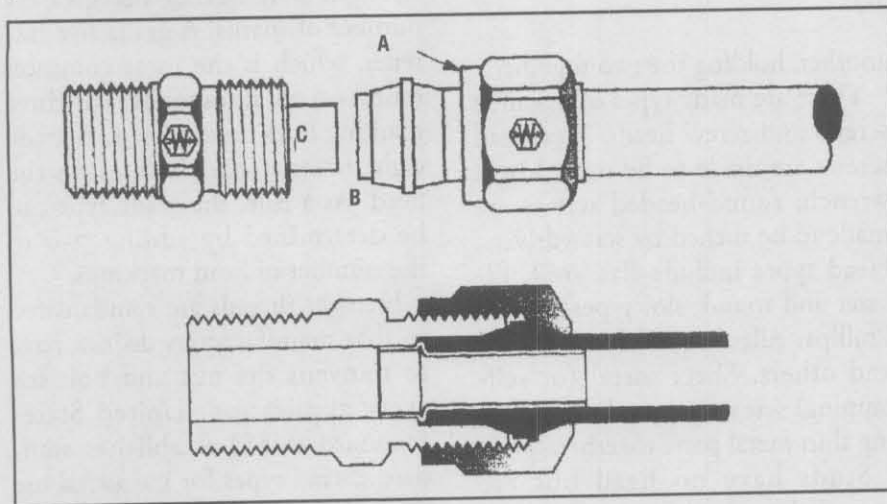
Brake lines should be steel and use a double flare fitting; they should never be cut and fitted with compression fittings. A double flare means that not only is a cone shape put on one end, it is also doubled in on itself, making it in effect double walled at the flare. The proper repair of a brake line involves replacing the entire damaged section, double-flaring the ends and using a flare line union.

Compression fittings can be used on low-pressure applications such as vacuum, fuel or lubrication lines. Compression fittings are named for the sleeve that fits around the tubing and is compressed onto it by a nut that is turned onto the fitting body. Compression fittings may be used on metal or plastic tubing. Soft plastic tubing requires an insert to prevent the sleeve from crushing the tubing.

Pipe fittings use a special tapered thread for a leak proof seal. As the fitting components are drawn together, the bottom and top of the



Compression fitting for rigid tubing.
(Courtesy: Boston Weatherhead/Dana Corp.)



Compression fitting for nylon tubing: A-Compression Nut B-Compression Sleeve or Ferrule C-Insert. The insert keeps the soft tubing from being crushed by the sleeve. (Courtesy: Boston Weatherhead/Dana Corp.)

threads come in contact before the sides; final tightening causes full metal-to-metal contact and the tight seal. A variety of fitting shapes and designs are used, including elbows and tees as well as those used to connect pipe thread to tubing or hose.

Barbed fittings are used to connect low-pressure hose to another piece of hose, a port or outlet, or another fitting. One end will have a series of ridges or barbs that the hose slides over and locks onto. The other end may have any number of pipe or flair type connections depending on its intended use.

Unions connect sections of tub-

ing and are designed for disassembly without turning the tubing.

There are various methods used to describe and measure air conditioning fittings. Many aftermarket hoses are assembled by the counterperson from an assortment of fittings and hoses. The air conditioning catalog should be reviewed for details on the types of hoses and fittings used for refrigeration. Since the late 1980s, most manufacturers have produced standardized O-ring type fittings for air conditioning applications. The SAE 45-degree fitting can still be found on older vehicles and many aftermarket add-on units.

HOSE

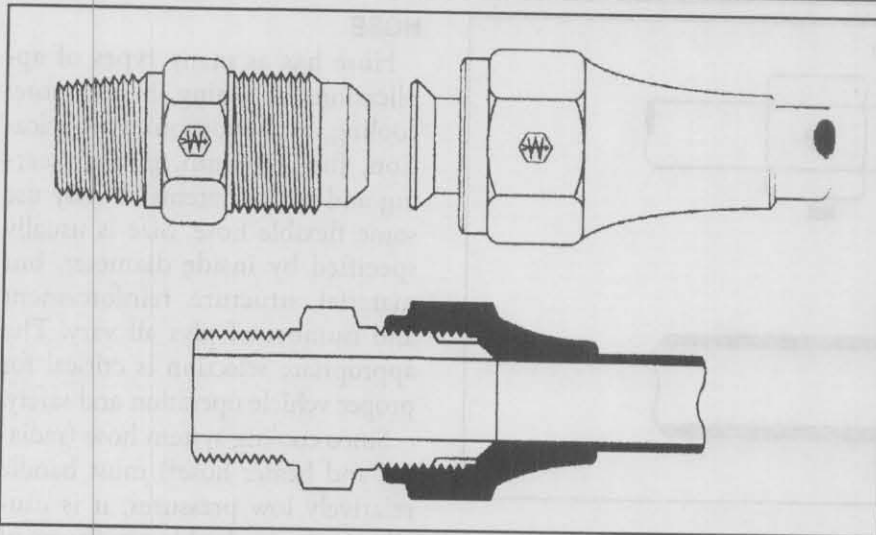
Hose has as many types of applications as tubing, if not more: cooling, air conditioning, lubrication, fuel, vacuum, power steering and brake systems all may use some flexible hose. Size is usually specified by inside diameter, but material, structure, reinforcement and number of plies all vary. The appropriate selection is critical for proper vehicle operation and safety.

Since cooling system hose (radiator and heater hoses) must handle relatively low pressures, it is usually single- or double-ply (layers of fabric within the rubber). It may be straight (capable of only slight bending), curved (molded into bends for specific applications), or flexible (designed to bend for universal applications, usually accordion-pleated with steel wire insert). Most hose made for cooling system use is not suitable for fuel systems, however. Fuel system hose is made of neoprene material that is fuel-resistant; if non-fuel rated hose is used, it may quickly deteriorate and expand or melt, causing a leak and possible fire.

Power steering and brake hose are of multiple-ply construction for high pressure use, and are available pre-made for specific applications. These come with any necessary threaded fittings already permanently attached.

Non-reinforced hose is used for many applications including vacuum lines, windshield washer fluid lines, drain and overflow hoses, and so forth. These appear similar to fuel hose, but should not be used with fuel as the hose may not be fuel-resistant.

Air conditioning hoses are designed to handle high pressures, and are usually of a reinforced nylon design. It's important to note the type of refrigerant used. The hoses used with different refrigerants (e.g., R12 and R134a)



SAE 45 degree flare as used on some A/C and oil lines.
(Courtesy: Boston Weatherhead/Dana Corp.)

may not be made of the same material and may not be compatible if used with the wrong type of refrigerant. On air conditioning hoses, the inside diameters are smaller than the outside measurement or nominal description would indicate. Inside hose diameter can usually be determined by measuring the outside diameter and then using a catalog chart from your hose provider.

Fasteners

Major automotive parts and systems may be the 'stars' of the automobile, but without all the 'bit parts' played by the fasteners, the car would fall apart. The automotive parts specialist will often be asked to provide replacements for these small parts.

Different types of threaded fasteners are used on automobiles. All feature a spiral groove (threads) that has been machined in. Bolts, screws, studs and nuts are common types of threaded fasteners. Machine screws and bolts resemble each other, with both having a head and a threaded shaft. But a bolt is designed to be used with a nut to hold two parts together; a machine screw passes through one component and threads into

another, holding the two together.

There are many types of machine screws and screw heads. Hex head screws are made to be turned by a wrench; round-headed screws are made to be turned by screwdrivers. Head types include flat, oval, filister and round; slot types include Phillips, Allen, torx, clutch, fluted and others. Sheet metal (or self-tapping) screws are used for fastening thin metal parts together.

Studs have no head but are threaded on both ends. One end is turned into a threaded hole in a part, and the other end is threaded for a nut to hold a second part to the first. The threads may be different sizes on each end, or the stud may be threaded for the full length.

Nuts come in a variety of styles as well. The common 6-sided nut is called a hex nut. Styles of hex nuts include castle and slotted hex. Distorted thread and soft collar nuts are types of locknuts designed to resist loosening.

Washers are discs that fit under screw heads or nuts, to distribute more evenly the force of the screw head or nut or, in the case of lock-washers, to keep the fastener from loosening. Cotter pins are hairpin-

like devices used with drilled bolts and slotted or castle nuts as a locking device. They are also used to secure linkage joints.

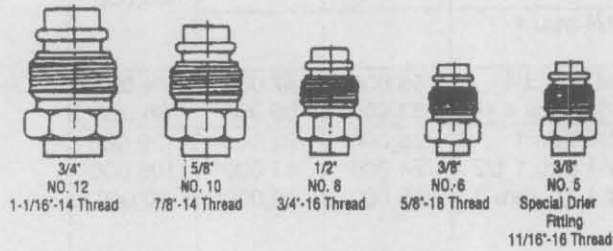
Steel bolts and cap screws are made to varying quality standards; higher-strength fasteners are used in critical areas or where high strength is required, justifying their greater expense. Markings on the head indicate strength ratings. Heads with no marks are used in most cases and indicate ordinary or low strength. Stronger bolts have in order of strength-three, four or six marks, with the highest strength bolt having the greatest number of marks. A grade five fastener, which is the most common found on an automobile, has three marking lines on the head. A grade eight fastener has six lines on the head. As a rule, the grade type can be determined by adding two to the number of head markings.

Fastener threads are standardized so that manufacturers do not have to reinvent the nut and bolt for every application. United States Standard (USS) establishes standard thread types for industrial use and this is commonly called coarse thread or UNC. The Society of Automotive Engineers (SAE) approves thread types for automotive use and these are known as fine thread or UNF. Metric fasteners are also available in different thread pitches but they are identified by size only. For example, an 8 millimeter bolt would be either 8x1.25 or 8x1.0 depending on how many threads per millimeter the bolt has.

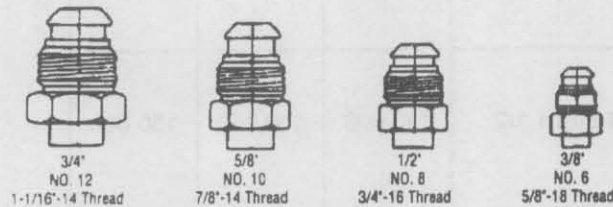
Thread pitch measures the distance from the crest of one thread to the crest of the next. A thread-pitch gauge, which looks like a collection of miniature saws, is used to measure thread pitch. For a given bolt size, coarse or fine threads may be used. While some people may refer to a bolt size by the wrench required to turn it, the

FITTINGS

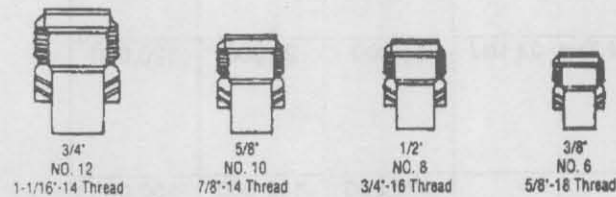
REFRIGERATION FITTING CHART



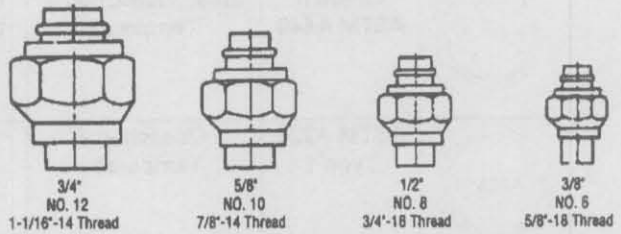
MALE O-RING



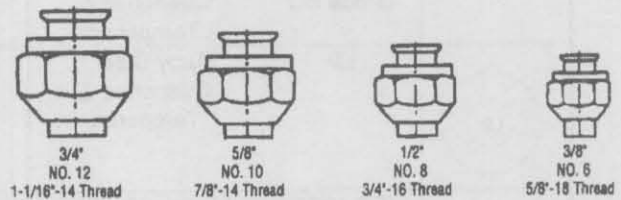
MALE FLARE



MALE INSERT O-RING

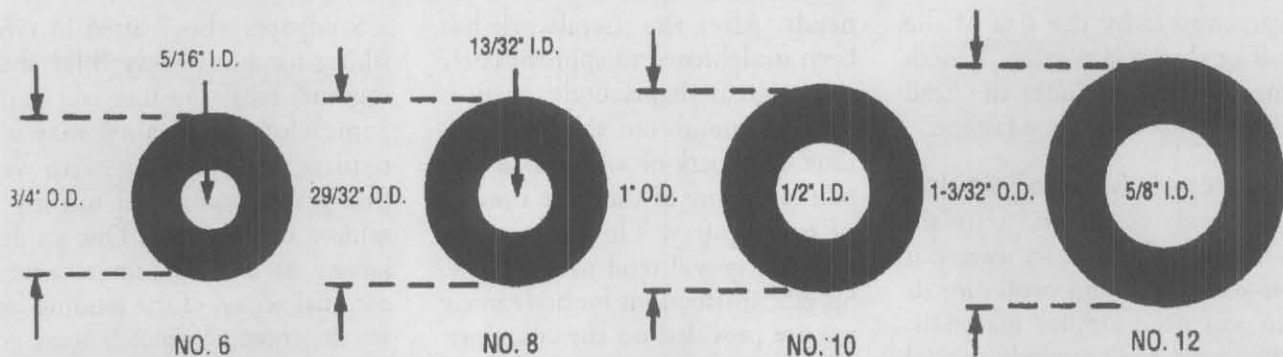


FEMALE O-RING










FEMALE FLARE

REFRIGERATION HOSE SIZE CHART



This chart illustrates the inside and outside diameters of refrigeration hose as well as some of the fittings that may be used with them. (Courtesy: Comfort Temp Corp.)

Identification Grade Mark	Specification	Material	Nominal Size Range (in.)	Proof Load (psi)	Yield Strength Min. (psi)	Tensile Strength Min. (psi)
	SAE J429 Grade 1	Low or Medium Carbon Steel	1/4 thru 1 1/2	33,000	36,000	60,000
	ASTM A 307 Grades A&B	Low Carbon Steel	1/4 thru 4	-	-	
	SAE J429 Grade 2	Low or Medium Carbon Steel	1/4 thru 3/4 Over 3/4 thru 1 1/2	55,000 33,000	57,000 36,000	74,000 60,000
	SAE J429 Grade 5	Medium Carbon Steel, Quenched & Tempered	1/4 thru 1	85,000	92,000	120,000
	ASTM A449		Over 1 thru 1 1/2 Over 1 1/2 thru 3	74,000 55,000	81,000 58,000	105,000 90,000
	ASTM A325 Type 1	Quenched & Tempered	1/2 thru 1 1 1/8 thru 1 1/2	85,000 74,000	92,000 81,000	120,000 105,000
	SAE J429 Grade 8	Medium Carbon Alloy Steel, Quenched & Tempered	1/4 thru 1 1/2	120,000	130,000	150,000
	ASTM A354 Grade BD	Alloy Steel, Quenched & Tempered				
	L9	Alloy Steel, Quenched & Tempered	1/4 thru 1 1/2	145,000	155,000	180,000
	ISO R898 Class 8.8	Medium Carbon Steel Quenched & Tempered	4 MM Thru 24 MM	85,000	92,000	120,000
	ISO R898 Class 10.9	Alloy Steel Quenched & Tempered		120,000	130,000	150,000

Bolt grade markings and ratings. (Courtesy: Hi-Ten Industrial Products)

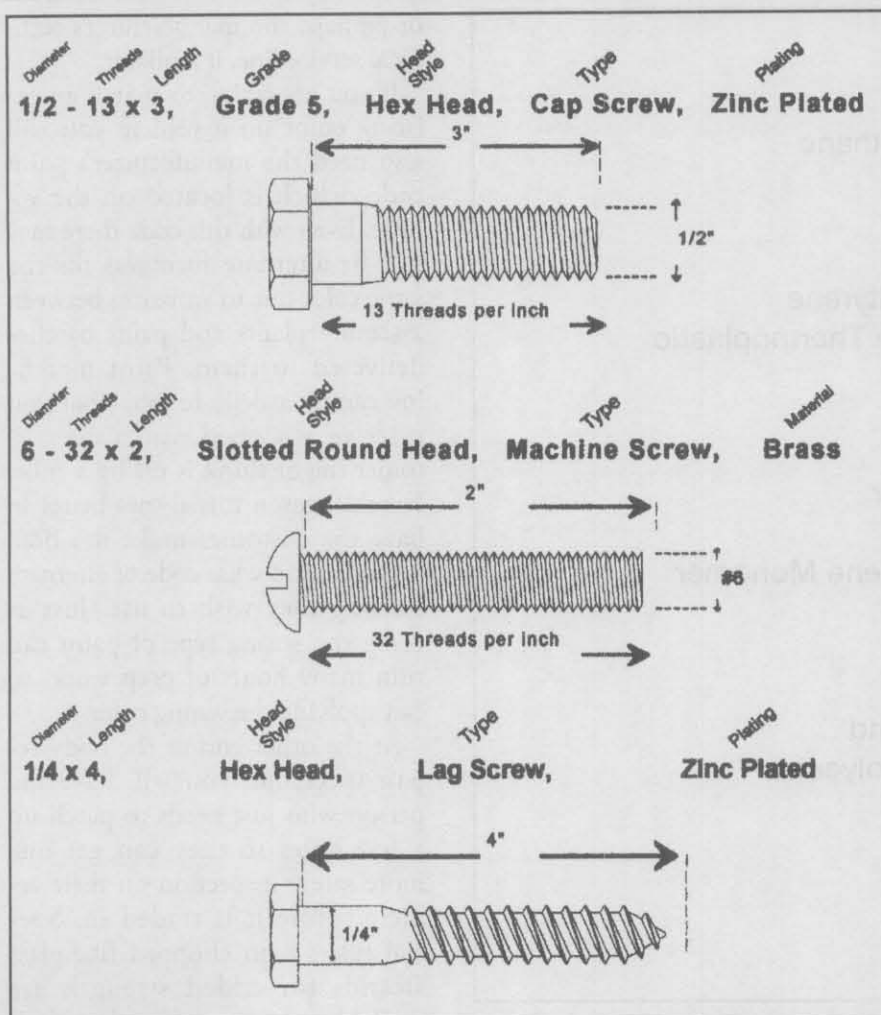
proper way is by the size of the shank or threaded portion. Length is measured from under the head to the extreme end of the fastener.

Body Repair And Refinishing

Auto body repair and refinishing is an art form all its own, but do-it-yourselfers and professionals alike will need similar materials. Body repair tools include special hammers and dollies to straighten bent metal; these come in various sizes and curves to meet various

needs. After the metalwork has been straightened to approximately the original shape, body putty is used to smooth out the final contour. The mark of a good body repair is the use of the least amount of body putty. Thickly-applied body putty will tend to work free. Specific instructions for body putty use are provided on the container. Cleaners and solvents are also used in body work; they help prepare the metal for body putty or refinishing.

Sandpaper also is used in refinishing for both body filler shaping and scuff sanding old paint. Some clear coat paints may also require wet sanding with very fine grade paper, and buffing to achieve a good finish. Disc sanders, known as DA sanders because of the dual action of the sanding face, are the most commonly used type of power sander. Round sanding discs are available for such tools in a variety of grits as well as methods of attachment to the backing



How bolts are measured. (Courtesy: Hi-Ten Industrial Products)

pad. In line or board file sanders, which use a 23/4 x19 inch paper, are used for rough shaping filler on flat panels. A hand file known as a cheese grater is also available for hand shaping and roughing in filler. Small hand held sanding blocks are used in final and clear coat sanding so that the paper is held flat and firm on the work. If no block is used, it is often possible to detect pressure lines where the technician's fingers pressed on the paper.

Sandpaper coarseness, or grit, is measured with the finest grit having the largest numbers—for example, 800 grit is finer than 400 grit. Grits are available from an extremely coarse 36 for metal and filler shaping, up to 1500 or more

for wet sanding clear coat. Sandpaper is also available in wet and dry varieties. Wet sandpaper is finer grit and is used for smoothing base and finish coats prior to buffing. Water is used in this final sanding step to float away dust and sanded material and the paper used must have a waterproof backing or it will fall apart.

Many vehicles also have plastic panels in place of traditional steel ones. These panels require their own special prep and painting techniques as opposed to steel. Traditional body fillers may not stick to them, and it may be necessary to identify what type of plastic you are dealing with before repair materials can be chosen. Painting procedures may also require a flex

additive for the base, color or clear coats to prevent them from cracking as the panel flexes.

Three or four basic types of automotive paints are used in a typical refinishing job. Primer, which bonds the color coat to the metal, and sealer, which is used to seal in old finishes and prevent bleed through, are the under coats. Next comes the color coat, the paint that you see, and if used, a clear coat, which is a transparent final finish that protects and enhances the color coat. These paints are available in different formulas as well.

Early automobiles were usually painted with some form of synthetic enamel type of paint. Total cure time could take up to thirty days or more although the vehicle could be delivered usually within 24 hours of being sprayed, and durability was not very good. Synthetic enamel gave way to acrylic lacquers in the 1960s and '70s. These offered quicker cure times and higher gloss than enamels but durability was still a problem. Enamels tended to fade and chalk up while lacquers could crack and peel. Lacquers can't be applied directly over an enamel finish either, as the solvents in the lacquer will attack and lift the enamel. Acrylic enamels with an isocyanate based activator were developed in an effort to fix the durability problems, but even with the added hardness provided by the activator, fading and chalking were still a problem. Today just about every mass produced vehicle is painted with some form of urethane based paint covered with a urethane clearcoat. These combine the gloss of a high quality hand rubbed lacquer with excellent durability in today's harsh environment. They also offer color choices and effects well beyond anything that came before them, but they also bring with them their own unique techniques and hazards.

As with any automotive repair, safety is of utmost concern. The

FLEXIBLE PLASTICS

PUR Polyurethane
TPUR Thermoplastic Polyurethane
 And similar plastics

RIGID PLASTICS

ABS Acrylontrile Butadiene Styrene
E/P-TPO Ethylene/Peopylene Thermoplastic
PC Polycarbonate
PP Polypropylene
TPO Thermoplastic Olefin
TPE Thermoplastic Elastomer
UP Polyester Thermoset
EPDM Ethylene Propylene Diene Monomer
 And similar plastic

EXTRA RIGID PLASTICS

SMC Sheet Molded Compound
FRP Fiberglass Reinforced Polyester
PC/ABS
HPA Honda Polymer Alloy
PPO/PA Rigid Polymer Alloy
GTX Alloy blend of nylon
 And similar plastics

Paint suppliers catalog page showing the different types of plastics used in exterior body panels and how they are classified.
 (Courtesy: SEM Products)

materials used in today's urethane based paints, especially the isocyanates used in hardeners and activators, are deadly. Prolonged exposure to fumes and vapors can cause irreparable damage to the human central nervous system. The only sure way to protect against them is to use a supplied air respirator in conjunction with a spray hood that covers the entire facial area. The old style charcoal masks that were used with lacquer paints will do nothing to stop isocyanates from entering the body. Care also must be used when sanding old paint or body filler. Everyone working within the immediate area should use, at the minimum, a paper dust mask.

If your facility mixes automotive paints, and you are asked for a recommendation on what materials to use, make sure the information you give is absolutely correct. Since most paint manufacturers base their results and reputation on using their own materials in a complete system, be absolutely certain that what you sell is compatible with everything else. Certain types of paint will attack and lift undercoats if the proper sealers are not used. Many hours of surface preparation and body work can be ruined by using the wrong thinners or reducers used in color or clear coats. If you have any doubts about what to use, ask someone that does, either another parts specialist

or perhaps the manufacturer's technical service line, if available.

If you are trying to match an existing color on a vehicle you will also need the manufacturer's paint code, which is located on the vehicle. Even with this code there may still be alternate formulas for the same color due to variances between assembly plants and paint batches delivered to them. Paint matching can be a delicate job, what you perceive as a good match the customer might think is off by a mile. For this reason it is always better to have the customer make the final decision as to what code or alternate shading they wish to use. Just as using the wrong type of paint can ruin many hours of prep work, so can applying the wrong color.

At the other end of the body repair spectrum, you will have the person who just needs to patch up a few holes so they can get one more safety inspection on their vehicle before it is traded in. Special fillers with chopped fiberglass strands for added strength are available, as well as fiberglass cloth and liquid resin patch kits. These will do a good job of repairing the hole but they can't be finished to as smooth a surface as regular filler. Sheet metal, pop rivets and cans of spray paint are also items that someone doing this type of repair might want.

The average DIY customer may only be looking to repair a small scratch or chip in their paint. Small bottles of touch-up are available that have a brush built into the cap and are used like a nail polish. The customer will need to provide you with a vehicle color code in order for you to select the right paint and a bottle of clear may also be required if the vehicle is painted with a base/clear system.

Chemicals And Appearance Products

The average parts store will carry a large number of chemical and appearance enhancing products for just about everything anyone could ask for. The more you know about how and what they do the better and easier your sales will be.

Service chemicals include such things as brake parts cleaner, carburetor cleaner, electrical contact cleaner, penetrating oil and various lubricating sprays. Their name implies their use although they can have many different applications, depending on the customer. Other items such as cooling system stop leak, fuel injector cleaner, and oil and transmission additives are pretty much limited to their intended use, but the customer may still have his own ideas. Be aware of customers who are trying to 're-build an engine from a can' and let them know that even the best additives in the world are no remedy for worn rings and tired bearings. This doesn't mean that you shouldn't promote your products, but be certain that you are not promising what they can't deliver. Some cleaners and lubricants may be incompatible with certain types of plastics and rubber and cause them to melt or warp. Therefore, a warning to the customer may be in order here also. There are a number of non-toxic biodegradable cleaners on the market that are safe for most surfaces and materials, and these might be a better choice in some instances.

Appearance products such as cleaners and waxes can be one of the biggest DIY categories in your store. Even people with no mechanical knowledge at all can have a desire to make their vehicle look good. Specialized cleaners are available for carpeting, vinyl, leather and any other surface found on a vehicle interior. Protectants are also available to keep vinyl and leather

in good condition after cleaning.

Waxes are available in many different forms of application and usage. They range from the very easy to use, such as all in one wash and wax, to multi-stepped cleaners and waxes for use with power buffers. If the vehicle has a finish in good condition, with no fading or scratching, a coat of wax is usually all that's needed. If the finish is in poor shape, a cleaner or compound may be necessary to restore it before a final waxing. Many manufacturers offer a complete system of cleaners and waxes that are meant to be used in a step-by-step process to achieve the advertised results, so be sure to mention this to customers looking to restore a neglected finish. Also be certain that they are compatible with the finish on the vehicle; some cleaners and compounds will scratch clear coats and leave them looking worse than before.

Wheels require another specialized area of cleaning products. Many vehicles are equipped with aluminum alloy or chromed wheels and road dirt and brake dust can make them tarnished and dull looking. Spray cleaners are available for both clear coated and rough cast alloys as well as chromed surfaces. These are usually meant to be sprayed on and hosed off, but some scrubbing may be required on heavily caked on dirt.

Finally, don't forget glass cleaners and waxes as well as new wiper blades. After the vehicle is cleaned inside and out, a glass wax such as Rain-X® can be applied that causes water to bead up and blow off the windshield and other glass surfaces. This approach is no substitute for good windshield wiper blades, however. Acid rain and UV rays can cause deterioration of rubber blades, making them streak and eventually tear. If the rubber tears enough, it can allow the metal wiper frame to contact the glass

and scratch it beyond use. Since it's recommended that blades be replaced twice per year, suggest that the customer change them spring and fall. These are times when motorists are thinking more about their vehicles anyway.

Special Application Belts

At some point you will probably be asked for a drive belt not used in an automotive application. This may be for a lawn mower or other piece of power equipment, shop air compressor, or even a furnace blower motor. In many cases a customer may simply come to you with the old belt and ask you to match it up. Power equipment and industrial belts may appear similar to an automotive belt but are constructed to withstand different types of loads and conditions. Automotive belts run with a fairly steady amount of tension and load on them, while an industrial belt may be subjected to numerous on/off cycles and varying tensions applied by idler and tensioner pulleys. In many outdoor power equipment applications an idler or tensioner pulley is used on the top side of the belt, and a standard automotive V belt will not last long under these conditions.

The part number on an industrial belt will also indicate its size. A single letter, or an alphanumeric designator indicates the top width and the digits that follow indicate the length in inches. The length designator is not always what it seems however. For instance, an A series belt with the number A40 indicates a 0.50-in. top width and a length of 42-in. Length designators vary between the different series of belts so you should always check your catalog to be sure.

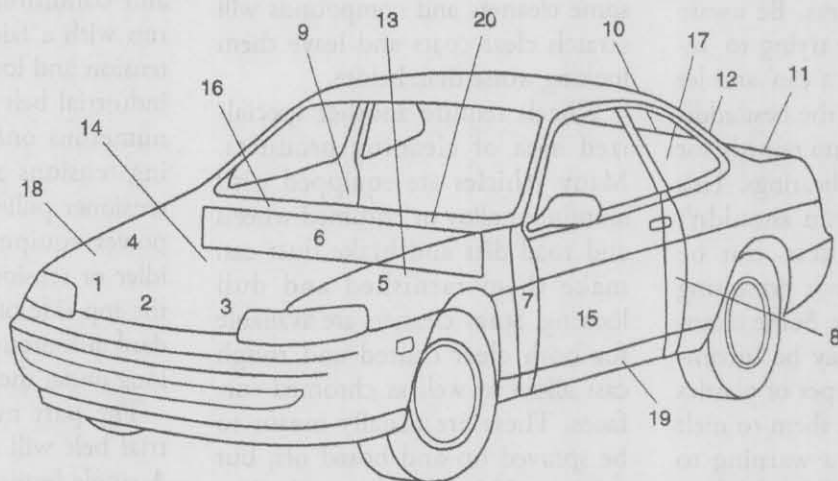
Micro V belts are also used in applications such as shop air compressors and power tools among others. Unlike automotive serpentine belts, these come in different

Car & Truck Identification Plate Locations

Emplacement des plaques d'identification dans les voitures et camions

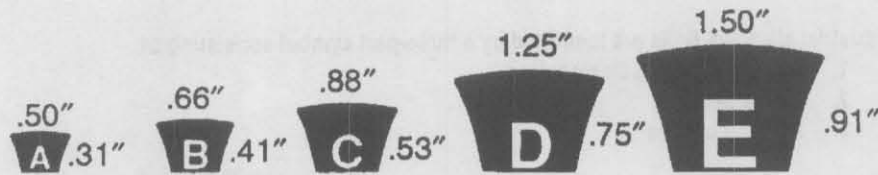
Localización de las placas de identificación de los carros y camiones.

KEY	LEGENDE	CLAVE
1 Front support-passenger side	1 Cadre avant - côté du passager	1 Soporte frontal - lado del pasajero
2 Radiator support-center	2 Support de radiateur - centre	2 Soporte del radiador - centro
3 Front support-driver side	3 Cadre avant - côté du conducteur	3 Soporte frontal - lado del chófer
4 Wheel housing-passenger side	4 Passage de roue - côté du passager	4 Guardafango - lado del pasajero
5 Wheel housing-driver side	5 Passage de roue - côté du conducteur	5 Guardafango - lado del chófer
6 Firewall-engine compartment	6 Tablier	6 Pared protectora del calor
7 Door pillar-driver side	7 Pied de porte - côté du conducteur	7 Pilar de la puerta del lado del chófer
8 Door jamb-driver side	8 Montant de porte - côté du conducteur	8 Quicio/borde de la puerta del lado del chófer
9 Door jamb-passenger side	9 Montant de porte - côté du passager	9 Quicio/borde de la puerta del lado del pasajero
10 Deck lid-passenger side	10 Couvercle de coffre - côté du passager	10 Tapa del baúl - lado del pasajero
11 Deck lid-driver side	11 Couvercle de coffre - côté du conducteur	11 Tapa del baúl - lado del chófer
12 Inner rear compartment	12 Intérieur du coffre arriere	12 Compartimiento interior de la parte trasera
13 Strut tower-driver side	13 Jambe de suspension - côté du conducteur	13 Eje de suspensión - lado del chófer
14 Hood underside	14 Capot - dessous	14 Interior de la capota
15 Driver door panel pocket	15 Panneau de porte - côté du conducteur	15 Bolsillo del lado de la puerta del chófer
16 Glove box	16 Boîte à gants	16 Guantero
17 Spare tire cover	17 Housse de roue de secours	17 Cubierta para llanta de refracción
18 Attached to battery tray	18 Fixée au bac de la batterie	18 Enganchado a la charola de la batería
19 Body plate	19 Plaque de la coque	19 Placa de carrocería
20 Cowl panel	20 Tôle de coffrage	20 Placa de la bóveda del tablero



MODEL MODELE MODELO	POSITION EMPLACEMENT POSICIÓN	MODEL MODELE MODELO	POSITION EMPLACEMENT POSICIÓN	MODEL MODELE MODELO	POSITION EMPLACEMENT POSICIÓN
ACURA	6,8	FERRARI	10	MINI	1,6,10,16
ALFA ROMEO	4,8,11	FESTIVA	7,8,9	NISSAN	1,6,7,8
AMC	7,8	FIAT	4,6,11	OPEL	1,2,3,4,5,6
AUDI	10,11,12	FORD / LINCOLN / MERCURY	7,8,19	PEUGEOT	2,3,4,5,6
AUSTIN ROVER	8,15	GM	2,10,11,12,16,17,20	PORSCHE	7
BMW	4,5,8	GMC TRK / VAN	9,15,16	ROVER	1,3,4,5
CAPRI	8	GEO	10,11,16	SAAB	5,6
CHRYSLER		HONDA	6,8	SATURN	11,12,17
Car / voitures / carro	1,2,6,8,13,18	HYUNDAI	1,5,6,7,8	STERLING	7
Imports / voitures importées / vehículos importados	6,10	ISUZU	6,7,8,9,16	SUBARU	1,3,13
Truck & van / camions et fourgonnettes / camión, camioneta	2,5,6,8,14,19,20	JAGUAR	7,8	SUZUKI	6,16,17
DAIHATSU	1,6	KIA	20	TOYOTA	6,8,15
DATSUN	2,6	LAND ROVER	8	VOLKSWAGEN	10,11,12
DAEWOO	2	LEXUS	8	VOLVO	2,5
		MAZDA	8	YUGO	10
		MERCEDES BENZ	2,8,19		

This chart shows common locations for vehicle paint color codes. (Courtesy: Dupont Performance Coatings)



Our Belt No.	Length In inches	Our Belt No.	Length In inches	Our Belt No.	Length In inches	Our Belt No.	Length In inches	Our Belt No.	Length In inches
A Section		A Section - Cont.		A Section - Cont.		B Section		B Section - Cont.	
A24.....	26	A55.....	57	A87.....	89	B28.....	31	B60.....	63
A25.....	27	A56.....	58	A88.....	90	B29.....	32	B61.....	64
A26.....	28	A57.....	59	A89.....	91	B30.....	33	B62.....	65
A27.....	29	A58.....	60	A90.....	92	B31.....	34	B63.....	66
A28.....	30	A59.....	61	A91.....	93	B32.....	35	B64.....	67
A29.....	31	A60.....	62	A92.....	94	B33.....	36	B65.....	68
A29.8.....	31.8	A61.....	63	A93.....	95	B34.....	37	B66.....	69
A30.....	32	A62.....	64	A94.....	96	B35.....	38	B67.....	70
A31.....	33	A63.....	65	A95.....	97	B36.....	39	B68.....	71
A32.....	34	A64.....	66	A96.....	98	B37.....	40	B69.....	72
A33.....	35	A65.....	67	A97.....	99	B38.....	41	B70.....	73
A34.....	36	A66.....	68	A98.....	100	B39.....	42	B71.....	74
A35.....	37	A67.....	69	A99.....	101	B40.....	43	B72.....	75
A36.....	38	A68.....	70	A100.....	102	B41.....	44	B73.....	76
A37.....	39	A69.....	71	A103.....	105	B42.....	45	B74.....	77
A38.....	40	A70.....	72	A105.....	107	B43.....	46	B75.....	78
A39.....	41	A71.....	73	A110.....	112	B44.....	47	B76.....	79
A40.....	42	A72.....	74	A112.....	114	B45.....	48	B77.....	80
A41.....	43	A73.....	75	A115.....	117	B46.....	49	B78.....	81
A42.....	44	A74.....	76	A120.....	122	B47.....	50	B79.....	82
A43.....	45	A75.....	77	A124.....	126	B48.....	51	B80.....	83
A44.....	46	A76.....	78	A128.....	130	B49.....	52	B81.....	84
A45.....	47	A77.....	79	A133.....	135	B50.....	53	B82.....	85
A46.....	48	A78.....	80	A136.....	138	B51.....	54	B83.....	86
A47.....	49	A79.....	81	A144.....	146	B52.....	55	B84.....	87
A48.....	50	A80.....	82	A158.....	160	B53.....	56	B85.....	88
A49.....	51	A81.....	83	A173.....	175	B54.....	57	B86.....	89
A50.....	52	A82.....	84	A180.....	182	B55.....	58	B87.....	90
A51.....	53	A83.....	85			B56.....	59	B88.....	91
A52.....	54	A84.....	86			B57.....	60	B89.....	92
A53.....	55	A85.....	87			B58.....	61	B90.....	93
A54.....	56	A86.....	88			B59.....	62	B91.....	94

This chart shows the top width and depth as well as part number variation from actual sizes of letter series industrial belts. (Courtesy: Gates Rubber Co.)

cross sections, or pitch, between the ribs as well as number of ribs. The part numbers for these consist of a three-digit number representing the length, a letter representing the cross section, and a number denoting the number of ribs. As an example, a 795L6 belt is 79.5-in. long, has a 3/16-in. spacing between the ribs, and is 6 ribs wide. Most manufacturers offer a separate catalog listing lawn and garden applications as well as size charts

and cross references for selecting industrial type belts. Be certain that the belt you sell is not only the correct size but is able to carry the load that will be placed on it.

Performance Parts And Customizing Accessories

In addition to people looking for repair and maintenance items you will also have customers looking for ways to customize or personal-

ize their vehicles. There is a whole segment of the aftermarket that is dedicated to performance and appearance products only. This segment includes everything from car covers, to accessory lighting, to suspension lifts, to exhaust systems, and much more. These can be very profitable and rewarding items to sell but it may also require a higher degree of salesmanship and product expertise than repair parts.

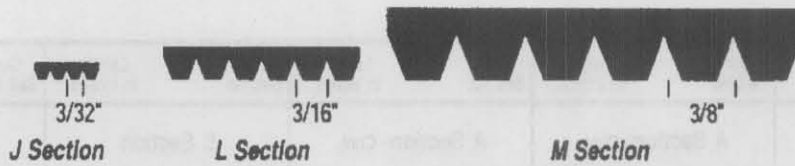
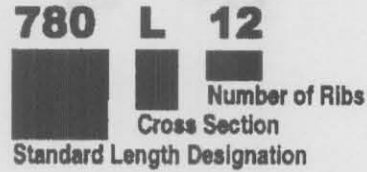
The customer who comes to you

Industrial Micro-V® Belts are identified by a three-part symbol consisting of:

1. Standard Length Designation
2. Cross Section
3. Number of Ribs

For example, the belt designation **780L12** represents:

- (1.) 78.0" In Length
- (2.) L Cross Section
- (3.) 12 Ribs Wide



J Section - including 4, 6, 10, 16 and 20 ribs
L Section - including 6, 8, 10, 12, 14, 16, 18 and 20 ribs
M Section - including 6, 8, 10, 12, 14, 16, 18 and 20 ribs

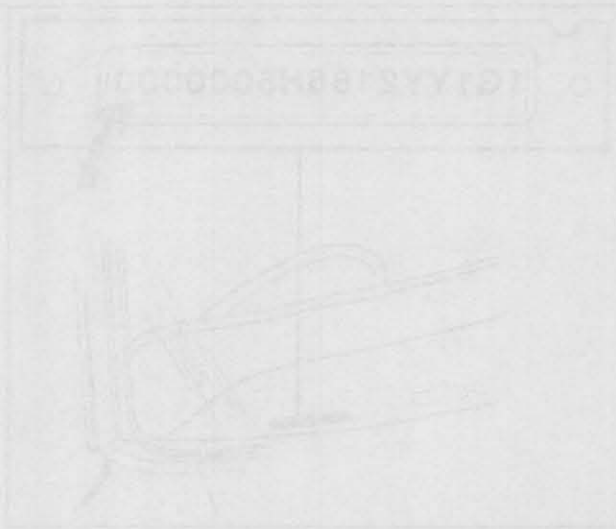
This illustration shows how industrial Micro V belts are sized and numbered. (Courtesy: Gates Rubber Co.)

looking for a water pump is there because their vehicle is broken and has to be fixed. The customer who comes to you looking for a tuned exhaust system or bug deflector does not absolutely need it, so they will probably be more selective in what they buy. In these cases you may have to determine not only the specific wants of the customer but also the manner in which the

vehicle will be used. Suspension and exhaust modifications, for example, may void the vehicle warranty or violate state safety codes. In some cases these types of parts are listed by the manufacturer for off road use only, and you should make your customer fully aware of the consequences of installing them. Even items such as auxiliary lighting and window tint film

are subject to regulations regarding their use so be careful of what you recommend and how you sell it. Unless your store specializes in or stocks these types of parts, you may only be dealing with a picture and description in a catalog, so make certain that you have all of the necessary information and specifications before ordering.

Vehicle Identification



For vehicles in the U.S. registered in 1981-1984, the VIN is 17 characters long. The first three characters (1G1) represent the manufacturer, the next six (YYZ18) represent the vehicle's model, and the last eight (00000000) represent the vehicle's production sequence.

The VIN is a unique identifier for each vehicle. It is located on the front of the vehicle, usually on the driver's side of the dashboard. The VIN is a 17-character alphanumeric code that provides information about the vehicle's manufacturer, model, and production sequence. The first three characters (1G1) represent the manufacturer, the next six (YYZ18) represent the vehicle's model, and the last eight (00000000) represent the vehicle's production sequence. The VIN is used for identification and tracking of vehicles throughout their life cycle.

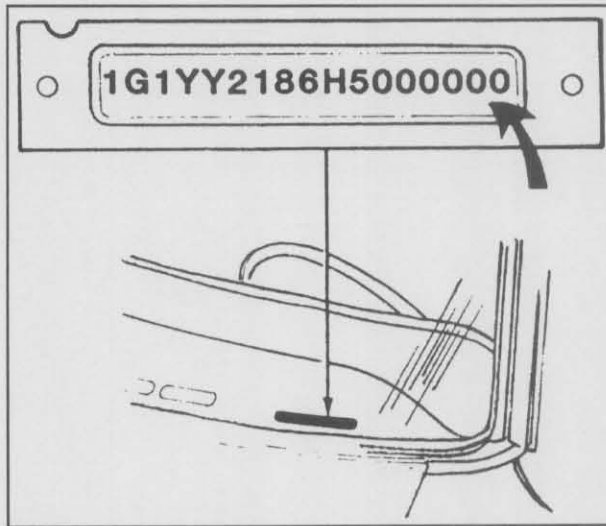
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Vehicle Identification

Accurately providing parts to the customer requires that you first know the vehicle on which the part will be used. The basic starting point has always been year/make/model but this is often not enough anymore. The US auto industry has for years introduced their new models in September, meaning that a vehicle produced and sold in the months after that were considered to be the following years model. This does not always hold true today. It's possible to see vehicles produced in almost any calendar month being identified as either the previous years model or a new model year. The only certain way to tell is through the VIN, or Vehicle Identification Number.

Since 1981, cars and light trucks sold in the U.S. have been assigned a 17-digit VIN number that can be found on a plate at the top of the dash panel on the driver's side. The VIN plate should always be visible through the windshield. Certain digits of the VIN are consistent between manufacturers. For example, the first digit identifies the nation of origin, the second digit identifies the vehicle manufacturer, and the tenth digit is the year, while the eighth digit usually describes the engine. The amount of information the VIN contains varies by manufacturer, but always includes model year, manufacturing assembly plant, body style, and engine option. The final digits are always the sequential serial number, a number that is assigned to



For vehicles sold in the U.S. beginning in 1968, the VIN number must be stamped on a metal tab attached to the instrument panel, in a place where it is visible through the windshield from outside the vehicle. (Courtesy: GM Corp.)

vehicles in the order of production, with higher numbers usually indicating later production. In some cases, such as on many German built vehicles, the manufacturing plant also assigns a chassis number as well. This can be found on a plate attached to the firewall, and while it does not contain the same information the VIN does, it may be critical in identifying the correct replacement part for that car. A shop manual or online reference may be used to decipher these VIN codes, or it's highly likely that your computerized part catalog will decipher it and filter some of the qualifiers for you. Often times you may only be asked for a certain digit or letter from the VIN, such as the engine identifier, but if you are in doubt ask for the whole VIN rather than assume.

In addition, beginning with

1970 model vehicles, a sticker with the month and year of manufacture appears on the B-pillar near the door latch striker plate or on the rear edge of the driver's door itself. This production date can be very important for identifying mid year changes made during a production run. Some vehicle manufacturers, Ford for instance, may also place an option code sticker here that refers to certain aspects of how the ECM/PCM is programmed as well as transmission or axle codes. Stickers or data plates listing individual axle weight ratings and gross vehicle weight ratings for trucks may also

be found here as well, and some manufacturers may also list paint code and interior trim numbers in this area. Sometimes however additional data such as paint codes and other finish information is found on trim tags fastened to the body near the radiator, on the firewall, or in similar locations. There is no standard location for any information other than VIN, weight ratings, and production date so some searching may be needed to find the required information.

Shown here is a sample VIN number and what each character represents:

SAMPLE VIN **2GCEK19K3M1196682**

From this you can determine the following:

- 1st digit=country of origin, in this case Canada

- 2nd digit=manufacturer, GM
- 3rd digit=make, Chevrolet, Buick, etc. In this case Chev. Truck
- 4th digit=GVW and brake system, 6001 to 7000 GVW with hydraulic brakes
- 5th digit=chassis type, Conventional cab 4x4
- 6th digit= series type, ½ ton
- 7th digit=body type, Extended cab
- 8th digit=engine type, 5.7L V-8 fuel injected Chev. Truck Canadian built.
- 9th digit=check digit only
- 10th digit=model year 1991
- 11th digit= plant where built, Wentzville
- 12th thru 17th= sequential serial number.

Identifying body styles is another thing you need to become familiar with. Where one manufacturer may give cars built on the same chassis completely different names, others may only designate them by body style or a letter designation,

such as Honda's Civic DX, LX, or EX. Another example is Chrysler's Sebring, which was available in coupe, convertible or sedan versions. These differences in body style can make for very significant differences in brakes and suspension, making it imperative that you know how to identify them. Deciphering the manufacturers meaning sometimes requires some interpretation, as descriptions are often assigned by marketing specialists who prefer more enticing names than sedan, coupe and convertible. As an auto parts specialist you must be able to identify the primary body styles to provide parts for these cars. Terms used to describe body styles include:

Sedan: basic fixed-roof automobile, with front and rear seats holding four to six passengers; most often with four, but sometimes two or five doors.

Coupe: usually smaller than a sedan, with two doors, fixed roof, and smaller rear seat intended only for occasional use; typically 'sport-

ier' than a sedan.

Convertible: a sedan or coupe with a top (usually made of fabric) that can be lowered or removed for open-air motoring.

Roadster: typically a convertible-type car, though lighter in weight, sportier, and with a more rudimentary top. This is a very old designation and is not used anymore by the major manufacturers.

2+2: a car with front bucket seats and occasional rear seating for two. Also a very old designation.

T-Top: a roof with removable panels for a quasi-convertible effect; named for the central post that connects the windshield header with the rear section of the roof, forming a "T."

Station wagon: a sedan with a roof that extends to the rear of the car for additional luggage/seating space.

Hatchback: a car with a top-hinged hatch (hence the name) at the rear that opens for access to the luggage space; differentiated from a station wagon by the sloping rear

VINformation

2006 G.M. PASSENGER CAR VIN SYSTEM

2 G 1 F P 2 2 K 7 6 2 1 0 0 1 7 4

1	2	3	4	5	6	7	8	9	10	11	12-17
WORLD MANUFACTURER IDENTIFIER	MANUFACTURER	MAKE	CARLINE/SERIES	BODY TYPE	RESTRAINT CODE	ENGINE TYPE	CHECK DIGIT	MODEL YEAR	PLANT	PRODUCTION SEQUENCE NUMBER	

1st Position of the VIN# (Vehicle Identification Number)

This digit breaks down the Country of Production for a vehicle sold in the U.S.A.

- 1=USA (Domestic Manufacturer)
- 2=Canada (All Manufacturers)
- 3=Mexico (All Manufacturers)
- 4=USA (Captive Imports and/or Joint Ventures)
- J= Japan (All Manufacturers)
- K=Korea (All Manufacturers)
- W=Germany (All Manufacturers)
- X=Former Soviet Union (All Manufacturers)

VIN Model Year ID 10th Character	Model Year
A	1980
B	1981
C	1982
D	1983
E	1984
F	1985
G	1986
H	1987
J	1988
K	1989
L	1990
M	1991
N	1992
P	1993
R	1994
S	1995
T	1996
V	1997
W	1998
X	1999
Y	2000
1	2001
2	2002
3	2003
4	2004
5	2005
6	2006

2006 G.M. PASSENGER LIGHT TRUCK & MPV VIN SYSTEM

1 G N D U 0 6 E 3 6 0 0 0 1 1 E X

1	2	3	4	5	6	7	8	9	10	11	12-17
WORLD MANUFACTURER IDENTIFIER	MANUFACTURER	MAKE	GVWR/BRAKE SYSTEM	LINE & CHASSIS TYPE	SERIES	RESTRAINT CODE	ENGINE TYPE	CHECK DIGIT	MODEL YEAR	PLANT	PRODUCTION SEQUENCE NUMBER

VIN plate interpretive information for GM vehicles. (Courtesy: Dupont Performance Coatings)

<p>FJD 2.5 LITER L1G2 5V5TPG6 LAO-1C</p>	<p>VEHICLE EMISSION CONTROL INFORMATION General Motors Corporation GM</p>		<p>25V5TPG6</p>	<p>EMISSION HOSE ROUTING</p>
<p>SPARK PLUG GAP 0.060 INCHES.</p>		<p>CATALYST EGR/TWC/02S</p>		
<p>NO ADJUSTMENT PROVISIONS EXIST FOR IDLE FUEL MIXTURE, IDLE SPEED, OR IGNITION TIMING.</p>				
<p>SEE SERVICE MANUAL AND MAINTENANCE SCHEDULE FOR ADDITIONAL INFORMATION.</p>				
<p>THIS VEHICLE CONFORMS TO CALIFORNIA REGULATIONS APPLICABLE TO 1990 MODEL-YEAR NEW PASSENGER CARS AND TO U.S. EPA REGULATIONS APPLICABLE IN CALIFORNIA.</p>			<p>PT. NO. 10136245 PRINTED IN U.S.A.</p>	

Sample VECI label showing engine size and family in upper left corner and model year in text at bottom.

window and smaller luggage area. A fold-down rear seat may give additional storage; may have two or four doors in addition to the hatch. You may also see references to three door or five door models. This is just a manufacturers way of designating a car as either a four door with a hatchback, or a two door with rear hatch.

Fastback: a car with a "sporty" sloped rear window that does not provide access to the luggage area (see hatchback); a fold-down rear seat may increase luggage space.

Hardtop: a contraction of hard-top convertible, the term refers to a car with no B-pillar (looks like a convertible with its top up); may be 2- or 4-door. Popular in the '50s, '60s and into the '70s, its popularity decreased with the rise of efficient air conditioning.

Van: box-shaped truck with an enclosed cargo area; may have seats for passengers or an area for cargo.

Minivan: smaller than the traditional van, seats five to eight passengers, or may be set up as a cargo carrier.

Pickup truck: truck with open cargo area behind the passenger cab; sizes range from mini to full-size pickups.

Sport Utility Vehicle: small truck or van, usually with 4-wheel drive. These vehicles are sometimes referred to as APV's (All-Purpose-

Vehicles), MPV's (Multi-Purpose Vehicles) or SUV's. They usually are of a frame design similar to that of a pickup truck, but can accommodate three to six passengers and have a rear hatch or door.

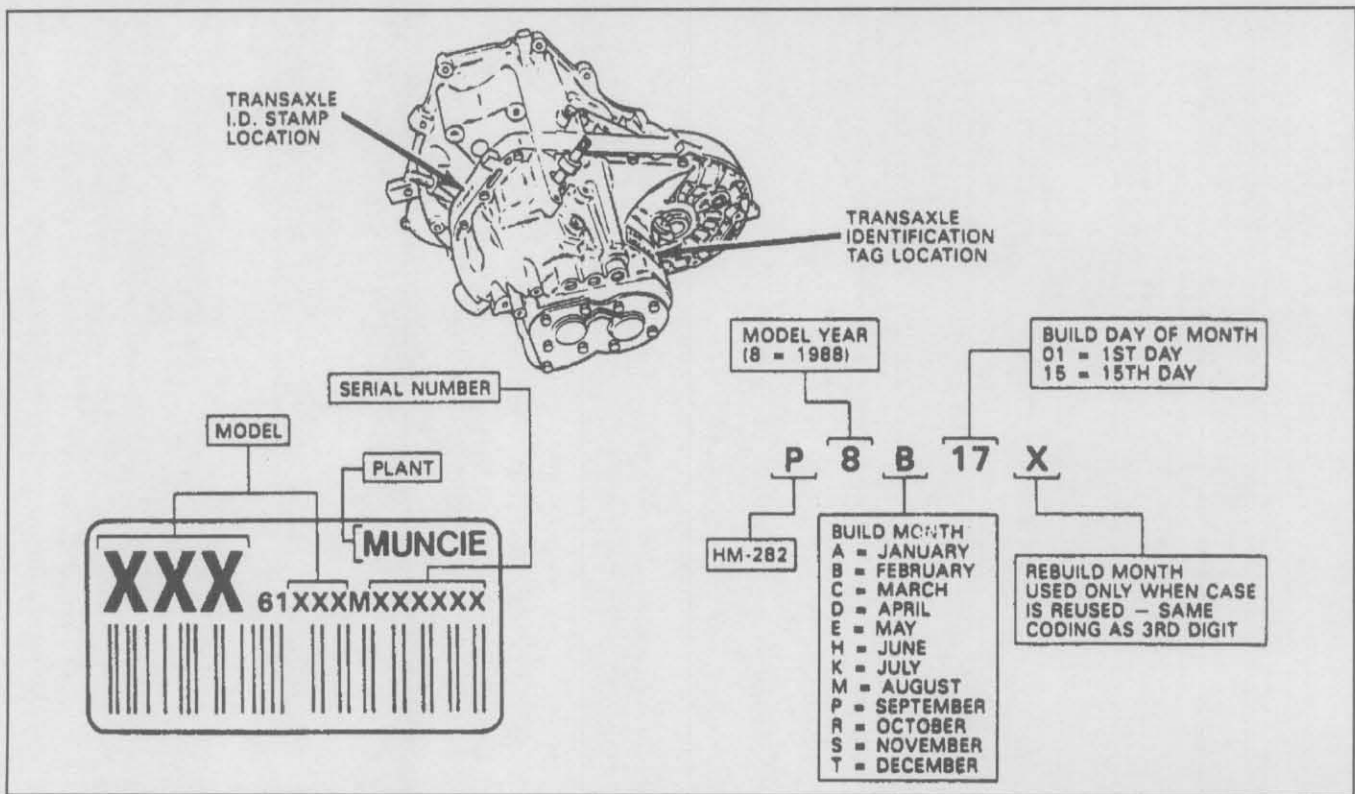
In addition to the various body styles, OEMs may also sell a basic chassis and engine combination or a cab and chassis combination to a utility body manufacturer. These may be made into rescue vehicles, motor homes, cargo vans used for local deliveries, or any number of other uses. The VIN number will indicate this or a plate may be attached stating the year and configuration the chassis was delivered in. This is very important informa-

tion to have, as certain safety and emission rules applied to a complete vehicle may not be applicable to vehicles delivered as cab and chassis.

Another way to identify the engine is the Vehicle Emission Control Information (VECI) label. Cars and light trucks built since the late 1970s have this required VECI label under the hood. The VECI label is located in the engine compartment, usually on the hood, radiator support or fender well. This label contains the specific engine identification information for the vehicle, including displacement and fuel system, if the vehicle has California, 49 state or 50 state

Service Parts Identification		DO NOT REMOVE		<p>Body Type/Style</p>	
VIN	1G1JD51P6H7000001	1JD69			
	ARL A02 A65 B6Y B9A B9K C60 D1B D35 E5Z E6E E9Z FLT GU1 JM7 K19 K64 LC3 MX1 M31 NA5 NB1 QMX VK3 VC2 VY1 VY4 V73 Y19 ZJ7 6BJ 62L 62U 67D 67I 679 7BJ 8HJ 9HJ			<p>Option Content</p>	
EXAMPLE					
DIS. LACQUER	WA-L8240	U8240	A4721	11T	67D
PRINTED IN U.S.A.		PART NO. 14065987			
<p>Paint Technology</p> <ul style="list-style-type: none"> • Solution Lacquer • Dispersion Lacquer • High Solids Enamel • Waterborne Enamel • Basecoat/Clearcoat 		<p>Paint Codes & Locations</p> <p>L - Lower Body Color U - Upper Body Color A - Middle Body/Accent Color (Striping, etc.)</p>		<p>Vinyl Top Color (If Applicable)</p> <p>Trim Combinations</p>	

The Service Parts Identification Label can assist in servicing and determining replacement parts. (Courtesy: GM Corp.)



Typical location and information contained on a transaxle ID tag.

emission controls. It will also show important emission specifications and setting procedures; as well as a vacuum hose schematic with various emission components identified. Because the label will often contain information regarding mid-production changes specific to engine and emission components, you should have the customer refer to it when requesting related parts.

Transmissions, axles, and other major components such as electronic controls, fuel pump modules, and brake calipers will also have some sort of identifying number on them. This may be a model type or casting number, or in the case of electronics and emission control parts, it is often the OEM part number itself. This number is required for electronics and emission controls due to the many options and vendors used by the OEM: no substitutions should be made unless specified. Wiring harnesses and fuel pump assemblies

may also have a tag with a letter or alphanumeric designator on them that is necessary to properly identify that part.

General Motors places a Service Parts Identifier, or SPID label on every vehicle it produces. This identifies all of the optional items and assemblies that were used in the construction of the vehicle, including paint and interior codes, brake options, transmission type, VIN number, etc. The information is listed as a three-digit alpha or alphanumeric code in alphanumeric sequence on the label. For example, if the catalog lists brakes as being either a JA1 or JA2 option, read down the tag until you come to the J listings to determine what you have. Information for deciphering these tags as well as VIN numbers is available through GM dealers or through on line resources. Finding the location of the tag can be difficult, as they have been put in such places as inner

trunk lids, glove box doors, and spare tire covers, so you may have to hunt a little bit.

Decoding information contained in the VIN is a much easier proposition for the OEM dealer. Computerization of the build information allows them to retrieve any information pertaining to their vehicles simply by keying in the VIN, sometimes only the last six or seven digits, and all of the installed options as well as paint codes will be displayed. This technology is not yet readily available to the aftermarket, but some of the parts manufacturers are starting to incorporate VIN driven information in their web sites to aid with locating parts from their own product line. In the event that you are faced with a choice in ordering parts it may be worth the effort to consult the OEM as to what the proper option might be before accruing special order or return charges due to errors.

Cataloging Skills

BRAKE SHOES AND PADS		Front Pad Set	Front Pad Shim	Rear Shoe/Pad Set	Rear Brake Size (D.D. x Width)	Rear Pad Shim
Year	Vehicle—Model					
CHRYSLER						
DISC BRAKE CARS						
300M						
2000-99	Except Export, Except Performance Handling Package	D730◇	N/A	D658	Disc	N/A
	Except Export, Performance Handling Package	D730◇	N/A	D658	Disc	N/A
	Export	D730◇	N/A	D782●	Disc	N/A
Cirrus						
2000	Rear Disc Brakes	D650●	DS8137	D641	Disc	N/A
	Rear Drum Brakes	D650●	DS8137	698	200 x 32.5mm	N/A
1999	Rear Drum Brakes	D650●	DS8137	716	200 x 32.5mm	N/R
	Rear Disc Brakes	D650●	DS8137	D641	Disc	N/A
1998-97	Rear Drum Brakes, Antilock Brakes	D650●	DS8137	716	200 x 32.5mm	N/R
	Rear Drum Brakes, Except Antilock Brakes	D650●	DS8137	698	200 x 32.5mm	N/R
1998-95	Rear Disc Brakes	D650●	DS8137	D641●	Disc	DS8101
1996-95	Rear Drum Brakes	D650●	DS8137	698	200 x 32.5mm	N/R
Concorde						
2000-98	Except Export	D730◇	N/A	D658	Disc	N/A
	Export	D730◇	N/A	D782●	Disc	N/A
1997-95	Rear Disc Brakes	D591●	DS8121	D658	Disc	DS8101
	Rear Drum Brakes	D591●	DS8121	657	220 x 40mm	N/R
1994-93	Rear Disc Brakes	D591●	DS8121	D415	Disc	DS8101
Conquest TSi						
1989-84	All	D258●	DS8037	D144	Disc	DS8012
Dynasty (Canada)						
1993-91	Rear Drum Brakes	D524●	DS8094	629●	220 x 40mm	DS8101
	Rear Disc Brakes	D524●	DS8094	D415●	Disc	DS8101
1990	Rear Drum Brakes	D478●	DS8058	629●	220 x 40mm	N/R
	Rear Disc Brakes, Bendix	D478●	DS8058	D415●	Disc	DS8101
	Rear Disc Brakes, Bosch	D478●	DS8058	D386●	Disc	DS8110
1989-88	Rear Drum Brakes	D385●	DS8058	520	220 x 40mm	N/R
	Rear Disc Brakes	D385●	DS8058	D386●	Disc	DS8110
Fifth Avenue						
1993-91	Rear Disc Brakes	D524●	DS8094	D415●	Disc	DS8101
	Rear Drum Brakes	D524●	DS8094	629●	220 x 40mm	N/R
1992-91	Parking Brake Shoe	N/A	N/A	643	172 x 20mm	N/R
1990	Rear Disc Brakes, Bendix	D478●	DS8058	D415●	Disc	DS8101
	Rear Disc Brakes, Bosch	D478●	DS8058	D386●	Disc	DS8110
	Rear Drum Brakes	D478●	DS8058	629●	220 x 40mm	N/R
1989-83	Except Police Car, Except Taxi	D84	DS8062	445	10 x 2½	N/R
	Police Car, Taxi	D84●	DS8062	446	11 x 2½	N/R
Imperial						
1993-91	Rear Disc Brakes	D478●	DS8058	D415●	Disc	DS8101
	Rear Drum Brakes	D478●	DS8058	629●	220 x 40mm	N/R
1992-91	Parking Brake Shoe	N/A	N/A	643	172 x 20mm	N/R
1990	Rear Disc Brakes, Bendix	D478●	DS8058	D415●	Disc	DS8101
	Rear Disc Brakes, Bosch	D478●	DS8058	D386●	Disc	DS8110
	Rear Drum Brakes	D478●	DS8058	629●	220 x 40mm	N/R
Intrepid (Canada)						
1994-93	Rear Drum Brakes	D591●	DS8121	657	220 x 40mm	N/R
	Rear Disc Brakes	D591●	DS8121	D415	Disc	DS8101
LeBaron						
1995	Sedan, Rear Disc Brakes	D524●	DS8094	D415	Disc	DS8101
1995-94	Rear Drum Brakes	D524●	DS8094	657	220 x 40mm	N/R
	Coupe, Convertible, Rear Disc Brakes	D522●	DS8094	D415●	Disc	DS8101
1994	Sedan, Rear Disc Brakes, Casting No 12205501, 12391901	D522●	DS8094	D415●	Disc	DS8101
	Sedan, Rear Disc Brakes, Casting No 12224901	D524●	DS8094	D415	Disc	DS8101

This catalog page is laid out with the product line 'Shoes and Pads' at the top of the page and individual years and models listed below. Other catalogs may list each vehicle model by itself, such as Chrysler Cirrus, and all of the products they make for that application with it. (Courtesy: Raybestos/Dana Brake and Chassis)

As a parts counter specialist you are the most important link in the aftermarket supply chain. Without your specialized skills and knowledge the journey a part or component makes from manufacturer to final user would be much more difficult and time consuming. The proliferation of OEM manufacturers and part numbers makes identifying and sourcing the right part at the right time much different than it was even a few years ago. Without proper identification and input from both the manufacturer and the customer this job would be impossible, and the cataloging system is where it all comes together. This section will deal with extracting what you need to know from your customer and interpreting the information provided by the manufacturers cataloging so you can perform your job well.

In the early days of both the automobile and the aftermarket obtaining the correct replacement part was not the specialized skill it is today. Vehicle manufacturers usually did not make radical changes very often, and much of the hardware and components were sourced from outside vendors. This meant that many different vehicles could be serviced from a much smaller base stock of parts, and the cataloging was also much simpler. Often all that was needed was vehicle year, make, and model. If you examine some of the parts catalogs from the 30s thru the 50s or 60s you will notice that they are usually very concise and brief in their listings. This meant that the catalogs could be much easier to interpret and needed less updating. As time and technology progressed that began to change. Vehicle manufacturers began to offer many more options and accessories on the same model car, including engine and drivetrain, which affected other systems such as brakes,

STUDS
 Replacement wheel studs may differ slightly from O.E.M. studs. The selected replacement stud must provide sufficient underhead length for full threading of the wheel nut, and sufficient for seating the stud into hub and drum.

THREAD SIZE, BOLT NO., L OR R HAND THREAD, LENGTH UNDER HEAD, KNURL DIA., SHOULDER LENGTH

 5740B (SM) 9/16"-18R X 3-3/16" 618 Knurl 1-23/32" Shoulder Length	
 5741B (CN) 9/16"-18R X 3-9/16" 630 Knurl 1-5/16" Shoulder Length	
 5775B (GT) 5/8"-18R X 2-3/16" 715 Knurl 19/32" Shoulder Length	
 5786B (JC) 5/8"-18R X 2-27/32" 680 Knurl 1" Shoulder Length	
 5800B (DG) 1/2"-20R X 2-3/16" 625 Knurl 1-3/32" Shoulder Length	 6006B (DB) 1/2"-20R X 2-3/32" 625 Knurl 1" Shoulder Length
 6010B (JV) 9/16"-18R X 2" 623 Knurl 3/4" Shoulder Length	 6012B (DE) 1/2"-20R X 1-13/16" 620 Knurl 13/16" Shoulder Length

Since conditions may vary from one vehicle to another, Raybestos disclaims any and all responsibility and liability for bodily harm or property damage as a result of the use of replacement studs and recommends that users consult with qualified replacement parts dealers.

Sample page of a wheel stud buyer's guide. This information can be invaluable when looking for non standard application parts.
 (Courtesy: Raybestos/Dana Brake and Chassis)

exhaust, emission, and electrical systems. If you also consider that many of today's cars are produced from globally sourced components, and that very few cars made today can truly be called purely American or German or Japanese, you'll understand why cataloging skills are so critical on every level of the supply chain.

In the days BC-Before Computers-catalogs were kept in large racks that took up lots of counter space, and you had to know which one to look in to find the desired part. This meant that a thorough knowledge of your stores product line and how to use those catalogs was critical. This is still true today even with electronic cataloging

Example:

Service Parts Identification														DO NOT REMOVE		
1G1AW1422F81ABC95																
AB3	A01	A52	B3W	B9K	C60	D14	D35	D71	E5Z	E7Z	E9Z	FA7	FA8	F17		
GB2	GB3	G92	JA2	K64	LR8	MD9	MX1	NA5	NK5	OKL	QFF	TR9	T63	UL5		
U25	U26	U27	U28	U29	VK3	V73	YT9	1AY	6JX	82D	82I	82L	82U	829		
7JW	SNU	9NU														

Bold : Brake System Option Code

The charts below will also assist you in determining the brake system option code:
1983-82 GM A-Body Brake Systems

- On some GM vehicles the gross vehicle weight can be used to better determine the type of brake system the vehicle is equipped with.
- Vehicle gross weight is on certification label on inside of driver's door.

GVW	BRAKE SYSTEM
Under 1670 KG	JA-6 Extra Light, Manual Brakes
1670 KG to 1784 KG	JA-1 Light Duty w/power brakes
1784 KG to 1815 KG	JA-8 Medium Duty w/power brakes
1815 KG to 2000 KG	JA-2 Heavy Duty w/power brakes
	JA-3 Wagon w/power brakes

10

GM Brake Codes

GENERAL MOTORS
1996-75 Car & Light Truck Brake Systems

Engine	Line	Option No.	Front Rotor	Rear Drum/Rotor	Power Booster
Gas	Pass. Car	J41	N/A	8.86" x 1.77"	N/A
Gas	Pass. Car	J56	N/A	11" x 2.00"	N/A
Gas	Pass. Car A-Body	JA1	9.86"	8.86" x 1.77"	8.75" Tandem Diaphragm
Gas	Pass. Car A-Body	JA2	10.41"	8.86" x 1.77"	8.75" Tandem Diaphragm
Gas	Pass. Car A-Body	JA3	10.41"	8.86" x 1.77"	8.75" Tandem Diaphragm
Gas	Pass. Car A-Body	JA8	10.41"	8.86" x 1.77"	8.75" Tandem Diaphragm
Gas	Light Truck	JB1	11.86" x 1.28"	11" x 2.00"	NONE
Gas	Light Truck	JB3	11.86" x 1.28"	11" x 2.00"	11" Single Diaphragm
Gas	Light Truck	JB5	11.86" x 1.28"	11.25" x 2.75"	11" Tandem Diaphragm
Gas	Light Truck	JB6	12.5" x 1.28"	11.25" x 2.75"	11" Tandem Diaphragm
Gas	Light Truck	JB7	12.5" x 1.28"	13" x 2.5"	11" Tandem Diaphragm
Gas & Diesel	Light Truck	JB8	12.5" x 1.53"	13" x 3.5"	Hydro-Boost
Gas	Light Truck	JB9	14.25" x 1.53"	15" x 4.00"	Hydro-Boost
Diesel	Light Truck	JD3	11.86" x 1.28"	11" x 2.00"	Hydro-Boost
Diesel	Light Truck	JD5	11.86" x 1.28"	11.15" x 2.75"	Hydro-Boost
Diesel	Light Truck	JD6	12.5" x 1.28"	11.15" x 2.75"	Hydro-Boost
Diesel	Light Truck	JD7	12.5" x 1.28"	13" x 2.5"	Hydro-Boost
Gas	Light Truck	JF9	14.25" x 1.53"	13.75" x 1.53"	Hydro-Boost
Gas	Light Truck S-Series	JM3	N/A	N/A	11" Tandem Diaphragm
Gas	Pass. Car	JM4	N/A	8.86"x1.77"	11" Tandem Diaphragm
Gas	Light Truck S-Series	JM5	N/A	N/A	9" Tandem Diaphragm
Gas	Light Truck S-Series	JM7	N/A	N/A	11" Tandem Diaphragm

Sample catalog page that translates GM brake codes into brake sizes and applications.
(Courtesy: Dorman Products/R&B Inc.)

and vendor supported web sites, if for no other reason than there might be times when you can't access the paper catalogs electronic counterpart. Knowing how to use

the paper however will pay back dividends in other areas as well. Depending on how your electronic cataloging is laid out sometimes a quick look at the book can save

lots of time and confusion.

The traditional paper catalogs are laid out beginning with a section on how to use the catalog, a table of contents, and then by

the specific listing pages. Additionally it may also have a specific part number index, and possibly an attached buyers guide. The users guide will tell you how search for the specific part you want by explaining the catalogs format. The table of contents will show the page numbers for various sections on the catalog, such as, abbreviation listings and their meanings, footnote designators and meanings, the actual part number listings by part type or vehicle manufacturer, and perhaps a part number index.

Depending on the product line it may be laid out in year/make/model format where everything within that manufacturers line is contained in one section, or it may be laid out by different components of a certain vehicle system with individual listings shown within that group. As an example, if you wanted brake pads and rotors for a Subaru Outback your catalog index may direct you to a section that lists all the possible Subaru options for year and model range that that particular catalog covers. It will then be broken down into sub group listings with brake pads in one group, rotors in another, and hardware in another. You would then have to choose the appropriate part numbers from within those listings based on specific year and model. The alternative might be if you were looking for a heater blower motor for the same vehicle. The table of contents could list every part that the manufacturer services for the heating and air conditioning system in it's own section of the catalog, such as blower motors in one section, blower resistors in another, valves and hoses in another, and other heating and AC related parts in their own section. Each section would then have sub group listings by specific vehicle make and

model.

No matter which basic format is used to get you to the proper section of the catalog you will then have to narrow your options down to the correct one. This often times involves more than knowing just year/make/model. Brake option choices, for example on Ford pickups of the same year/make/model, can vary widely and include such things as lining size, disc/drum or disc/disc combinations, or even the amount of wheel lugs and their size and thread pitch. This is why it's vital that you get all of the information needed from the customer first time around. Professional installer customers may not like having to hang on the phone while you look for their requested parts, but it's better than having to call them back and take them away from their job at hand, or sending them the wrong parts and having to wait for another delivery.

Once you are in the proper section of the catalog the various part number options for what you are looking for may each have their own line listing with the qualifiers next to them, or you may just see several numbers listed for the same application with footnote markers next to them. These markers will direct you to a list of qualifiers for that particular part, such as before/after production date, body style, casting number, or any thing that is needed to pinpoint the exact application for that part. Footnotes can be placed either at the bottom of the page they are referenced on, or grouped together in their own section of the catalog, and, may also contain drawings to illustrate the difference between to part choices.

You also need to pay attention to the abbreviations and terminology used in the different catalogs. Notations in the qualifiers such as FWD or AWD can denote four

wheel or all wheel drive, but not all of the abbreviations you see will be universally used in all catalogs. As an example, NA could be taken to mean "Not Available" as in not produced by the manufacturer, or "Not Applicable", meaning not used on this particular vehicle. If you are in doubt as to an abbreviation meaning always look for the explanation page rather than assuming anything. The terminology used between different aftermarket suppliers is also something you will have to learn to interpret. A brake manufacturers catalog for example may list brakes for a GM truck with either a JB7 or JB8 option. These designations come right off the SPID or Service Parts Identifier label on the vehicle, and are very easy to verify. They may however refer to these options as simply medium or heavy duty brakes, and leave it up to you to be able to interpret their meanings. Unfortunately there is no real industry standard regarding how these terms and qualifiers are used, either between the OEMs or the various aftermarket manufacturers. Product information gained from the OEMs by aftermarket manufacturers is open to the engineering and cataloging departments interpretation of how it should be applied and listed, and you may have a hard time finding two that do everything the same. This is where experience and knowledge of your product lines and cataloging skills, both paper and electronic, will pay off the most by getting the correct part the first time.

In addition to part listings catalogs may also contain cross reference sections, part number indexes, size listings, and illustrated buyers guides. These may be contained within the catalog pages, or supplied as separate stand alone publications, and they are extremely valuable resources to have.

BWD WELCOME TO THE **BWD** WEB SITE

ABOUT
PRODUCTS
CATALOGS
TECH TIPS
VEHICLE MAINTENANCE
PROGRAMS
TRAINING
HUMAN RESOURCES
CONTACT
LINKS

Pop: A
Part Number
RU1064

Part Number:

BLOWER MOTOR RESISTOR

Related Parts
* PT5793
**
**

Make	Model
CADILLAC	ESCALADE
CHEVROLET LIGHT TRUCK	AVALANCHE
CHEVROLET LIGHT TRUCK	FULLSIZE
CHEVROLET LIGHT TRUCK	SUBURBAN BLAZER
GMC LIGHT TRUCK	FULLSIZE
GMC LIGHT TRUCK	SUBURBAN JIMMY /

Sample page from an electronic on-line buyer's guide. The menu at the left allows you to access the on-line catalog section. From there you can either look up a part by application, or as in this case enter a known part number in the box at top and find the pertinent application data as well as illustrations. These can be invaluable in determining if you have looked up the correct part before placing any type of special order. (Courtesy: BWD Corp.)

Cross reference lists are important tools, as they are used to convert a competitor's or an OEM part number to yours, which can save you lots of time and trouble when looking for a part that has multiple options. They can be laid out in sections in alphabetical order by competitor's name, or just alpha-numeric by all competitors' part number with a cross to your supplier's part number. Attention must be paid though, as not everything listed will be a direct cross. The manufacturer may have determined that their part is an acceptable substitute for the part it's replacing, but may lack certain features or attributes. If you see a no-

tation such as "not a direct cross", or "check application listing" it's a good idea to go cross check with the application listings and make certain it's correct for your customer's requirements.

Part number indexes will often be found at the back of the catalog. These are an alpha-numeric list of all the part numbers contained within the catalog that direct you to the page or pages they are found on in the listing sections. This is helpful when trying to determine if the part a customer received was looked up for the wrong vehicle, or in cases where a part number has been superseded and or your customer still has old stock on the

shelf.

Size listings and buyers guides are provided to aid both the counter parts specialist and the purchasing department. A simple buyers guide will list all of the supplier's part numbers in alpha-numeric order and give a listing of what vehicles they fit, and each number may be assigned a popularity code. These are very helpful in determining if a part offered by the supplier is worth keeping on your shelf or better left as a special order item. The popularity code is assigned by the supplier, and is based on both how well that part sells in your geographic area, and official vehicle registrations for the application

that part fits. These will give the buyer an insight into how well they can expect that part to sell and also allow them to tailor inventory to their specific needs. For example, a set of ignition points that only fits air cooled Volkswagens will have a very low popularity rating and would under most cases be special order only. If however you have a VW restoration specialist in your area, or an active VW owners club with many members close by, it might be worth keeping a set in stock.

Illustrated buyers guides and size listings can be used by counter specialists to find parts that might not have a specific listing, such as the old truck that's had several engine and axle swaps over its life, been modified for other uses, or perhaps a belt that needs to be a different size than what's listed. They can also be helpful when the listing given in the catalog is incorrect and you need to find the right part, or you want to make sure the part you are about to special order is correct. A good illustrated buyers guide will list the part number, show a picture of it, and give any pertinent dimensions or attributes of that part that identify and differentiate it from the other part options you may be looking at. A good example of a combination buyers guide/size listing may be found in a shock absorber suppliers catalog. It will start with illustrations of the various upper and lower mounting methods and assign a code to each type and size. The shocks are then listed in alpha-numeric order along with their mounting codes and extended and collapsed length. Conversely they could be grouped by mounting code type and listed by extended/collapsed length, shortest to longest, or simply shortest to longest with the mounting codes listed next to them. No matter what the

format is, a picture is worth more than a thousand words in this case; making the buyers guides every bit as important as the catalogs themselves.

Paper catalogs are by nature static, meaning they are printed, issued, and distributed by the supplier and that's all that is ever done to them. Any updates or revisions must go through the same printing and distribution process, including technical bulletins the supplier might issue to address problems that arise between catalog issues. This means that at least yearly you will have to replace old catalogs or put additions or revisions in the rack with them as issued, including pricing sheets if you use them. Electronic cataloging has eliminated much of the need for the old paper catalogs and freed up all the counter space they occupied, but the basic need for product knowledge and updating remains the same. There are numerous electronic cataloging systems available today along with manufacturers web sites that perform the same functions as paper catalogs with just a touch on the keyboard or a click of the mouse, but you still need to be able to interpret the abbreviations and notations used, as well as understanding that particular suppliers terminology.

Electronic cataloging begins with entering the vehicle year/make/model and then selecting the major group the part belongs to, such as brakes. From there you will need to enter a sub group, such as front brakes, front brake hydraulics, or hardware and accessories. At this point part number qualifiers such as 2 or 4 wheel drive, engine or body style options, or any other major difference that might eliminate a series of listings from your possible options, are prompted. When these are answered your part number or numbers will be shown.

Just as with the paper catalog you may have to choose from numerous optional part numbers within that listing by interpreting their abbreviations and terminology, but often times the buyers guide resource is just a mouse click away. When looking at multiple brake rotor listings for the same vehicle for example just opening up the illustration and attributes box might show that one rotor is a different size or has a different number of stud holes than the other. This means you can ask only the pertinent questions without tying up excessive amounts of time. From there the correct part can be selected and added directly to the invoice or quote and printed. This assures that the customer gets the right part, and since cataloging is tied to invoicing, which is based on customer account numbers, that customer is always charged a uniform price for that part, no matter who invoices it.

Electronic cataloging also offers the option of looking for a part by word, or alpha, description. This means that if you don't know what group or sub group a part might be located in you can enter the part name and it will put you in the correct place. Depending on your product line and catalog provider however it may not be completely foolproof, so you still need a good knowledge of what you carry. It's also worth noting that while every effort is made to ensure that what's listed in the electronic cataloging is correct, mistakes and omissions can and will occur. For this reason you should be prepared to cross check with either the paper catalogs or the manufacturers web site if you have any doubts or problems with a part listing. This holds especially true on parts that must be special ordered or sourced from an outside vendor. The few extra minutes spent double checking is far

less than the time and aggravation wasted when the wrong part shows up at the customer's shop.

Just as with paper catalogs however electronic cataloging must also be kept updated, but this involves much less paper and sorting, and can be done much more frequently and economically than with paper. This may involve online data transfers from your cataloging provider, uploading from discs provided by suppliers, or handled by your company's own IT department. However it's done, make sure you know and understand what you need to do at your terminal/workstation whenever catalog maintenance is performed, if in doubt ask a supervisor or coworker rather than guess.

Along with electronic cataloging supplied by programming providers many manufacturers have set up extensive interactive websites to help promote their products. These can combine both a cataloging feature and a buyers guide in one. The same interactive prompts used in your regular cataloging program will bring you to the desired part number, but from there you may access several other areas that show pictures of the part from different sides, lists of all the possible applications where that part is used, part attributes and features, and related parts that might be needed when replacing it. In some cases the part lookup may be VIN driven, meaning all you need to enter is the vehicle VIN and all op-

tions but the correct one are eliminated. In some cases you may even be able to verify stock availability and pricing as well.

No matter what method you use to obtain your part number, it's important to remember that without the proper information from the customer and the proper application of that information by you, the chances of getting the right part at the right time are greatly reduced. Don't be afraid to ask questions and dig a little deeper in the resources that are provided to you, and never assume anything unless you're willing to assume responsibility for sending out the wrong part as well.

Inventory Management

A store's inventory is its single biggest expenditure and the reason customers come to you in the first place. A well managed and adequate inventory is essential to keeping your customers happy and coming back to you. This section will cover the ways you can help to make sure your store's inventory is kept in proper condition.

The cost of buying and stocking parts that go into your inventory is called the carrying cost. Since most stores will have a predetermined limit on how much they can spend on inventory, a good manager will try to keep carrying costs per item down so they can stock more. How often an item sells has a direct impact on carrying cost. Therefore, you will want to keep enough of a fast moving item (such as an oil filter), on hand to last for the amount of time for which your inventory is gauged. Inventory is gauged in 'turns' or number of sales of an item in a set time period. The decision on whether or not to stock an item depends entirely on demand. Obviously, an item that gathers dust on the shelf ends up costing you money in the long run, both in carrying cost and lost profit when the part is either returned to the vendor or scrapped. Another way to look at it: you know you are going to make a certain percentage of profit every time you sell a certain part. Therefore you would naturally want to keep enough of that part to satisfy demand. Too many of that part on the shelf means that money is tied up that could be making you a profit on other parts that should be stocked.

Too few of an item will result in lost sales that also reduce store profitability. Manufacturers may produce a popularity code listing for their products that show how well an item sells on a nationwide or regional average, but your best guidelines are lost sale reports and communication with your customers.

Lost sales reporting lets you know if you are not stocking an item that you possibly should. Most computerized point of sale systems will have a lost sale feature key, and will keep a running tally of how often sales are lost on an item. A sale is considered lost if the part is not on the shelf at the time requested. Even if a customer can wait, and has you special order what he wants, this should still be considered a lost sale. Any part not on hand at the time requested is a lost sale.

Computers used at the point of sale now track almost all store inventories. Daily sales are tabulated until a set reorder point is reached. Computerized tracking gives a quick, accurate picture of how fast an item sells and can allow you to keep less of that item on the shelf and still have enough to fill demand.

Before the widespread use of computers, inventory was tracked manually, usually by a card file system. This meant that each invoice had to be reviewed, and each item sold marked on its own tracking card. This card contained the number of that item stocked and how many had been sold. When the reorder point was reached, the number was added to the next order

placed.

Another way to track inventory is to have someone perform a physical inventory count and continually order what is needed. Obviously neither of the last two methods is as good as the first, but a physical inventory of all merchandise should be performed at least once a year. This will verify that your computer count is accurate and can also indicate if you have a theft problem. Most businesses are required to do this for tax and accounting purposes as well, and may have one person continually doing shelf counts of individual vendor lines on a rotating basis.

If you are selling a part that the computer or inventory says you have but you can't find, be sure to notify your manager or inventory control person. The reasons for discrepancies can be anything from improperly keyed part numbers, to theft, to items being used in house that were not charged out. An effort should be made to determine why the count is off or find out where the part went if possible. It could be that items such as oil and rolls of hose are received as case lots but are sold individually and someone may not be aware of the packaging change. Pricing can be a clue as to sales increments. A single foot of heater hose may sell for \$1.00, but certainly not a full roll. So be careful when working from bulk packaging. Also, be certain that any parts or materials used in delivery vehicle or store maintenance are properly charged out or accounted for, including the name of the person using the part and

which vehicle it was used on.

Incoming merchandise and returns to the vendor must be tracked as well as sold items. New stock received must be checked against the packing slips for shipping errors, and new parts returned to the vendor must be checked and deleted from inventory. Any non-stock or special ordered parts should also be checked against the packing slip, and the person who placed the order notified. Any special handling or shipping charges should be calculated at this point and noted on the packing or notification slip as well as the invoice number on which it was rebilled to your customer. This allows the inventory control person or bookkeeper to track who the part was ordered for and how much profit was made on the transaction. Warranty and core returns should be tagged as such and kept in a separate area away from new returns, so as not to mix them up.

When dealing with warranty returns, make sure you have all the proper information needed to return the part to the vendor. This may include date of original sale, documentation of original sale, date of replacement, miles in ser-

vice, and the nature of the defect. It is also important that at the point of sale the defective unit is not added back into the store's inventory tracking system. Most computerized systems will have a separate transaction code for new returned parts and warranty returned parts. If you are not careful you could put an item back into your electronic inventory that is not really on the shelf.

Care should also be used when dealing with core returns. Each item should be marked with a part number and labeled as a core to ensure proper credit is given when it is returned to the vendor. When taking back a core from a customer, make sure it is acceptable and complete; many vendors will also insist that the unit is returned in the original box it was shipped in when sold. Most rebuilders will only give partial credit for damaged or broken units. If you are in doubt as to the acceptability of a core, check in the printed catalog for the unit being sold. There should be a section explaining what to look for and how much to deduct for damaged units.

Some parts, such as carburetor or transmission kits, are usually pack-

aged in a sealed box and are not returnable if the package is open. However, if you determine that the reason for return is your error, you may have no choice. In this case you will have to make certain that the kit is complete and reseal it as well as possible. Special order parts, if returnable, may be subject to restocking fees or return freight charges, as well as the incoming freight being non-refundable, so be certain of what you order and check before accepting returns on them.

Stock rotation and lost sales reporting are also important in maintaining inventory. Stock rotation simply means to sell the oldest piece first, or 'first on the shelf, first to be sold'. By moving the older merchandise forward, any units with obsolete or faded packaging can be eliminated. This is particularly important with batteries. Most batteries will be date coded with an alphanumeric code for month and year, so be sure to sell the oldest first. Stock rotation is also very important with some paint related materials that might have a limited shelf life.

Merchandising

Merchandising is the term applied to the comprehensive function of sales promotion. It includes market research, product display, inventory selection and control, advertising, in-store signage, and promotional programs of all kinds. While the auto parts specialist may not have responsibility for store layout, he or she should understand the concepts behind the layout.

The amount of space in front of the counter compared to the amount of space behind the counter will vary, depending on the type of store, but 60% out front is generally desirable for self-service. The parts counter should be located at the rear of the store so that customers have to pass product displays on shelf units (called gondolas) to reach it. Ideally, the gondolas should be placed so that you can look down the length of them from behind the counter; this can help you spot customers who may need assistance and deter theft as well. When laying out display areas you need to keep in mind the different types of sales you are promoting. These include related sales items, seasonal items, destination items, and impulse sales items.

Related items should be displayed together. Related items are those that are used together or likely to be purchased at the same time. One example is tune-up supplies: spark plugs, distributor caps, plug wire sets and so on could all be displayed together. Another area might contain cooling system supplies, and feature belts, hose, thermostats, and cooling system additives and stop leak.

Seasonal items are those bought in greater quantities at a particular time of year. For example, anti-freeze and winter windshield wipers are seasonal items sold in the fall and winter. By placing them in conspicuous locations, such as at gondola ends or freestanding displays, customers will be reminded of what types of driving conditions they will be facing soon.

Destination items are those related to a destination, most typically vacation-type items. For example, summer season displays might highlight cooling system maintenance items for customers towing camper trailers. Winter destination items in cold climates might include tire chains or snowmobile belts and spark plugs.

Impulse items are those that the customer didn't come to the store for, but bought 'on the spur of the moment.' These are placed in high floor traffic areas, especially near the checkout counter (if the store has one), where everyone passes. These items are typically lower-priced and include products such as air fresheners, key chains and even sunglasses, although there is no strict price cutoff for impulse items. Related, seasonal and destination items can be sold as impulse items as well.

The location of displays is important to sales. The store floor plan should encourage customers to walk through the store (although they should not be forced to navigate a frustrating maze). Fast-moving items should be placed in the center sections of aisles or in dead areas to encourage customers to walk by other

items. Signs on gondolas not only identify product areas (for example, 'Oil & Lubrication'); they also aid traffic flow and help customers find the items they seek. Other sales aids such as stand alone displays and window signs should be kept neat and up to date, not left to fade and gather dust. Many brand name manufacturers team with racing and sports professionals to gain name recognition, and they provide advertising and sales aids to stores to promote this. By taking advantage of these offers you are taking advantage of millions of dollars worth of free advertising.

As much as possible, smaller items should be placed on upper shelves where they are more easily seen; large items may be kept on lower shelves. It also is recommended that brand-name items be displayed at eye-level, for faster customer recognition and greater sales potential.

Whenever possible, display items should be individually priced. People are less likely to purchase an item if they don't know the price. Bulk items such as oil need not be individually labeled, but the price should always be clearly displayed nearby. Cashiers should have a list of prices for fast-moving items to prevent misunderstandings. Hard parts, or replacement mechanical parts, can be exhibited on a display board, and if prices are listed, they should be stated in terms of 'as low as.'

Shelves should be restocked at least daily. Empty or even half-empty shelves raise doubts in the customer's mind about the quality

of the store and its ability to meet their needs. Likewise, merchandise should always be faced, or brought to the front of the shelf. It gives the store an attractive, uniform appearance, and facilitates stock ro-

tation, allowing new items to be added at the rear. Shelves and merchandise should also be kept clean; even dust on merchandise can be enough to discourage customers. Application and interchange lists

at display areas (for example, filter lists) should be kept up-to-date, and replaced whenever they show wear.

Notes

at least once the results are
listed should be kept up-to-date
and updated whenever the data
were

When allowing new items to be
added a certain number and set
amount should also be kept track
even that an individual can be
assigned to individual elements
Application and management data

of the state and its ability to track
them better. Likewise, organizations
should never be forced or pushed
to the limit of the field. It gives
the user an immediate history of
history, and history will be

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

NOTE: The following questions are written in the ASE style. They are similar to the kinds of questions that you will see on the ASE test. However, none of these questions will actually appear on the test.

- Parts Specialist A says merchandise should always be faced because it gives the store a neat and uniform appearance. Parts Specialist B says that facing the merchandise makes stock rotation easier. Who is right?
 - Parts Specialist A only
 - Parts Specialist B only
 - Both A and B
 - Neither A or B
- A physical inventory means:
 - stock that is heavy to lift
 - counting all the store's inventory
 - the value of the store's stock in the bookkeeper's records
 - the value of service work in the store's shop
- A customer can't decide whether to buy standard shock absorbers or upgrade to more expensive shock absorbers that have longer life and will give a better ride. He asks the Parts Specialist for advice. What should the Parts Specialist recommend?
 - the standard shocks, because customers are always happy with the lowest price
 - the upgraded shocks, because there's really no difference and the store makes more money
 - tell the customer to make up his own mind; that way he can't complain later
 - the upgraded shocks, because they're better and the store makes more money
- In October, an auto supply store sets up a display near the entrance selling windshield washer premix and winter windshield wipers. Using merchandising terminology, this is an example of:
 - related and seasonal items
 - impulse and obligatory items
 - confrontation and anxiety items
 - corresponding and autumnal items
- For security purposes, high-value items such as tools are often kept in locking display cases. As a rule, the display case can be left unlocked as long as:
 - needed to help the customer at the case
 - it takes to ring out another customer
 - the store is open
 - the tools aren't very small
- How is a traditional index in a catalog organized?
 - by vendor
 - by price order
 - by function
 - in alphabetical order
- An experienced Parts Specialist asked a customer for the car's engine size when the customer asked for shock absorbers. The Parts Specialist probably:
 - was trying to identify the model of car
 - thought that cars with different engines sometimes have different suspensions
 - was developing a marketing database
 - was going to promote related engine parts, hoping to sell more to the customer
- A customer asks where the Vehicle Identification Number (VIN) can be found on a 1988 model year car. Parts Specialist A says, "On a tag on the top of the dash on the driver's side." Parts Specialist B says, "On a tag on the passenger's door or B-pillar." Who gave the customer the right information?
 - Parts Specialist A only
 - Parts Specialist B only
 - Both A and B
 - Neither A or B
- To measure the thickness of a disc brake rotor, use:
 - an outside micrometer
 - an inside micrometer
 - a feeler gauge
 - a depth gauge
- The owner's manual of an older European car lists the engine's oil capacity at four liters. About how many quarts of oil is that?
 - two
 - four
 - six
 - eight

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

11. A connecting rod connects:
- A. the camshaft and rocker arm
 - B. the crankshaft and distributor
 - C. the crankshaft and output shaft
 - D. the crankshaft and piston
12. The purpose of valve seals is to:
- A. keep oil from leaking over the outside of the engine
 - B. keep oil from leaking down the valve guide
 - C. keep valves from allowing compression leaks
 - D. keep hydraulic lifters operating properly
13. A car with a DOHC V6 engine has how many camshafts?
- A. one
 - B. two
 - C. four
 - D. six
14. A customer buys a head gasket for a car that has an overhead camshaft driven by a timing belt. Which of the following should the Parts Specialist do?
- A. Ring up the sale. If the belt breaks later, it will mean more sales (replacing bent valves, etc.) at that time.
 - B. recommend replacement of the timing belt for the extra sale now
 - C. Ask if the timing belt on the car has visible wear. If it does, the belt may be ready to break and should be replaced.
 - D. for the sake of the store's reputation, refuse to sell the customer the head gasket unless he buys the timing belt
15. Parts Specialist A says a throttle body fuel injection system can have sequential fuel injection. Parts Specialist B says a multiport fuel injection system can have sequential fuel injection. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
16. Parts Specialist A says a spark plug with a heat range that is too hot can cause vehicle damage. Parts Specialist B says a spark plug with a heat range that is too cold won't cause vehicle damage. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
17. A resonator is part of the:
- A. ignition system
 - B. cooling system
 - C. sound system
 - D. exhaust system
18. The 'PCV' in PCV valve stands for:
- A. pollution control vortex
 - B. positive crankcase ventilation
 - C. piston clearance version
 - D. preignition combustion virago
19. An AIR (Air Injection Reactor) pump limits exhaust emissions by injecting air into the exhaust system. Parts Specialist A says this completes combustion of hydrocarbons. Parts Specialist B says it changes carbon dioxide to carbon monoxide. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
20. Torque multiplication is performed in a vehicle's:
- A. engine
 - B. transmission
 - C. electronic control computer
 - D. brake pads
21. A customer has called you and given you a part number from a filter that he has on the shelf. What section of the catalog would you look in to determine what it fits?
- A. the index
 - B. the table of contents
 - C. the footnotes
 - D. the part number index

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

22. Parts Specialist A says a transaxle is used in front-wheel drive cars. Parts Specialist B says a transaxle can be used in rear-wheel drive cars. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

23. Parts Specialist A says that the ring gear is part of the flywheel. Parts Specialist B says that the clutch disc is bolted to the flywheel. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

24. The three most common types of springs used in suspension systems are:

- A. hairpin, coil and shock
- B. hairpin, tension and compression
- C. compression, rebound and tension
- D. leaf, coil and torsion bar

25. The pitman arm connects the steering box to the:

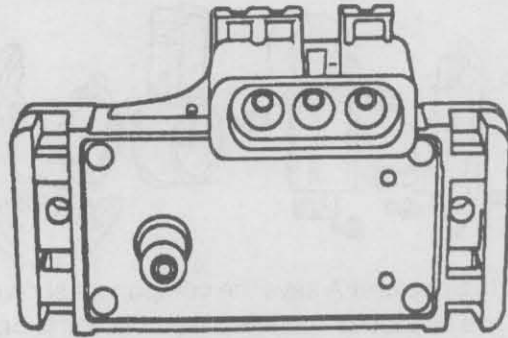
- A. center link
- B. idler arm
- C. tie-rods
- D. ball joints

26. Which of the following is NOT used to protect an automobile's electrical system against excessive current flow?

- A. fuse
- B. fusible link
- C. diode
- D. circuit breaker

27. Self-tapping screws:

- A. are also called sheet metal screws
- B. are designed so as not to over-tighten
- C. are designed to be used with a bolt
- D. can be used to hold one part on another, such as a carburetor on an intake manifold



28. Parts Specialist A says that the part shown above is a Manifold Absolute Pressure (MAP) sensor. Parts Specialist B says that the part shown is a Barometric Pressure (BP) sensor. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

29. Before replacing a MAP sensor, what else should be considered?

- A. condition of the exhaust manifold gaskets
- B. condition of the vacuum hoses
- C. condition of the AIR pump
- D. all of the above

30. A Parts Specialist is looking for a V-belt for a non-automotive application. What would he need to know to obtain one that will fit and perform properly?

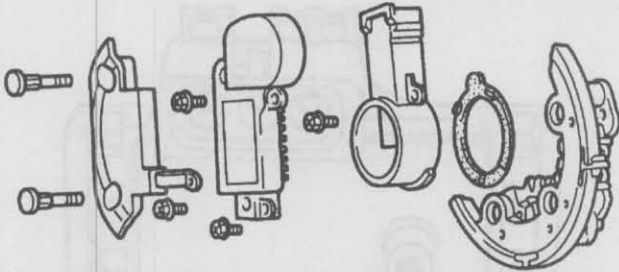
- A. length and top width of the old belt
- B. belt width and pitch
- C. belt diameter around the pulleys
- D. all of the above

31. The part shown here is a:

- A. pressure plate
- B. brake rotor
- C. clutch disc
- D. vibration damper



Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

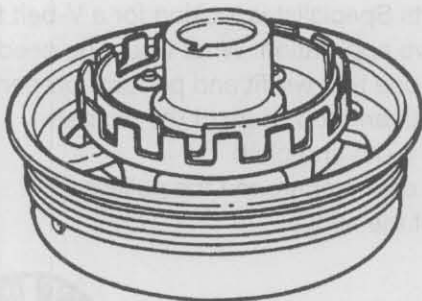


32. Parts Specialist A says the component shown above is a distributor module assembly. Parts Specialist B says the component shown above is an alternator regulator and brush assembly. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

33. A part you have special ordered from your regular supplier has just arrived at your store. The box has been opened and re-taped closed and there are greasy handprints on it. What should you do with it?

- A. Return it to the supplier.
- B. Ship it to the customer as quickly as possible.
- C. Open it and check the contents, try to verify that it is the correct part and has not been installed.
- D. Clean the package up and ship it.



34. Parts Specialist A says that the part shown above is an anti-lock brake toothed sensor ring. Parts Specialist B says that the part shown above is a crankshaft damper with crankshaft position sensor interrupter rings. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

35. A DIY customer returns a new radiator hose, and claims that as the engine cooled, the radiator hose collapsed. Parts Specialist A says that the hose is the wrong design, and should have had wire coil supports inside. Parts Specialist B says that this is caused by a defective thermostat. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

36. Parts Specialist A says that the thermostat controls maximum engine temperature. Parts Specialist B says if the engine continuously runs hot, you should sell the customer a cooler thermostat. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

37. A Parts Specialist has purchased a part from an outside vendor for \$5.25 and wants to make a 30% profit when he resells it. How does he figure the markup to achieve this?

- A. multiply 5.25 x .30
- B. add \$3.00 to the price
- C. subtract the cost price from \$30.00
- D. multiply the cost of \$5.25 by 1.43

38. An MSD sheet is a:

- A. Material Supply Demand sheet used for requisitioning parts
- B. Master Store Directory used for arranging catalog racks
- C. Material Safety Data sheet used to list properties of chemical compounds
- D. Master Spares Directory used to identify options installed on a vehicle

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

39. Parts Specialist A has just invoiced a part that Parts Specialist B has taken back as a return. When he goes to pull the part, Parts Specialist A can't find it on the shelf even though the inventory says it is on hand. Which of the following could be the reason for not finding the part?
- Someone stole it.
 - It was taken back as a new part when it should have been a warranty.
 - It was not returned to the proper shelf.
 - all of the above
40. A Parts Specialist wants a day off but management says he is needed that day. What should he do?
- complain to a coworker
 - complain to any customer who will listen
 - try to make his case as best as he can with management
 - quit
41. A Parts Specialist has looked up a set of shock absorbers through the computerized lookup, but the customer says they don't look like the right ones. What is the first thing he should do?
- Try to upsell the customer to better shocks.
 - Look in the paper catalog or the manufacturer's web site to verify the part number.
 - Look at a picture in the buyer's guide to see if they are boxed wrong.
 - Tell the customer that he must have given him incorrect vehicle information.
42. Which tool might see the most use behind a parts counter?
- dial indicator
 - dial indicating caliper
 - caliper resetting tool
 - digital micrometer
43. If a customer attempts to pay with a credit card and the sale is declined, you should:
- ask them for another card
 - ask them for another form of ID
 - ask them how they would like to handle the situation
 - ask them to pay their credit card bill and then come back
44. Parts Specialist A needs to know the engine size in a GM vehicle before he can look up an EGR valve. He tells the customer to look for it on the VECI label under the hood. Parts Specialist B says to look for the eighth digit of the VIN. Who is right?
- Parts Specialist A only
 - Parts Specialist B only
 - Both A and B
 - Neither A or B
45. A customer has requested a rebuilt master cylinder because the brake pedal travels to the floor and the fluid reservoir is empty. What other components should be checked and what else might he need?
- all lines and hoses and suggest brake fluid
 - wheel cylinders and calipers as well as brake linings
 - the power brake booster
 - all of the above
46. A DIY customer who does all of his own basic maintenance, such as oil changes and bulb replacements, is asking you about a halfshaft problem. Knowing that the job may be beyond his ability, what should you do?
- Sell him a service manual and tell him to read up on it.
 - Explain the procedure for replacing the halfshaft and remind him of the specialized tools and lifting equipment required, then let him decide if he wants to tackle the job.
 - Sell him a halfshaft and send him to a garage to get it replaced.
 - none of the above
47. A DIY customer has just priced a set of front brake pads from you and wants to know why yours are more expensive than the discount store across town. How should you reply?
- Tell him that yours is a higher quality pad.
 - Tell him that the other store's merchandise is all junk.
 - Tell him that the other store most likely looked them up incorrectly.
 - none of the above

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

48. Parts Specialist A is looking for a fuel pump for a 1999 GM truck. The catalog lists several options, depending on the tag number of the part. Parts Specialist A thinks this number is on the SPID label. Parts Specialist B says it will be on the part itself. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
49. A customer has returned a failed battery that was purchased 18 months ago. Since the battery had a one year free replacement before being pro-rated, Parts Specialist A says all that is needed is the original invoice and six months of pro-rate to be paid. Parts Specialist B says that you need the original invoice and 18 months of pro-rate charges. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
50. What do the markings on the head of a USS bolt indicate?
- A. grade or hardness
 - B. hex diameter
 - C. thread pitch
 - D. body diameter
51. A valued professional installer customer has called you up screaming because a new person on your counter has sent him the wrong part and the vehicle has to be finished ASAP. What should you do?
- A. ask him to call you back when he calms down
 - B. shout back at him so he will hear you
 - C. make sure you have the right part and tell him it will be delivered right away
 - D. act and speak calmly, get to the root of the problem and ask what he would like you to do
52. In the situation in question 51, what should you do after the problem is resolved?
- A. Remind the customer that the counterperson who sent the wrong part is new and that you will keep an eye on him and help him if he has problems.
 - B. Tell the customer to just ask for you whenever he calls.
 - C. Tell your manager or supervisor and let them deal with it.
 - D. Forget about it and move on.
53. What does it mean when an item in inventory is turned?
- A. The item is stock rotated.
 - B. It is returned to the vendor.
 - C. The item is sold.
 - D. The item is stolen.
54. A customer is walking through your display area, apparently searching for a certain item, while you are on the phone. What should you do?
- A. Ask the phone customer to hold while you assist the walk-in customer.
 - B. Ask the phone customer to hold, and ask the walk-in what they need and point to it.
 - C. Ask another person on the counter to assist the walk-in customer.
 - D. none of the above
55. What are some of the things that will cause an ECM unit to fail?
- A. voltage spikes
 - B. failure of another component
 - C. accident damage
 - D. all of the above
56. A customer has a pickup truck that he uses to carry heavy loads, and he wants to add more capacity to his suspension. Parts Specialist A says to install heavy-duty shock absorbers. Parts Specialist B says that shocks alone won't do, that the spring capacity must be increased also. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

57. An OBD II scan tool is used for:

- A. checking outboard dust boots on a halfshaft
- B. checking for outer body dents
- C. on-board diagnostics trouble code retrieval
- D. none of the above

58. A customer asks for a recommendation on restoring a vehicle's exterior paint. Parts Specialist A asks the customer how bad the finish is and how deeply he wants to get involved. Parts Specialist B says that all the customer needs is a good rubbing compound and wax. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

59. What is the difference between a metering valve and a proportioning valve in a brake hydraulic system?

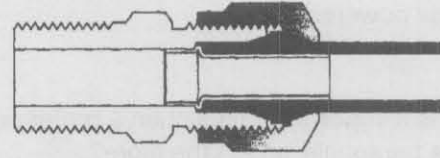
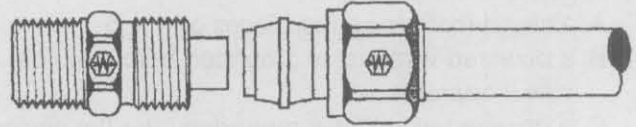
- A. nothing, they both limit brake application
- B. one limits brake pressure while the other controls brake timing
- C. both of the above
- D. none of the above

60. What are the two most common types of steering systems?

- A. rack-and-pinion and recirculating ball
- B. hydraulic and manual
- C. power and radial
- D. kingpin and ball joint

61. Which of the following is the **MOST** important reason to have an original invoice when processing a returned part?

- A. to prove that the customer bought it from you
- B. to verify that the money being refunded is not more than what was originally paid
- C. to harass the customer and hope he never returns anything else
- D. all of the above



62. The fitting shown above is a:

- A. bubble flare fitting
- B. double flare fitting
- C. collar fitting
- D. compression fitting

63. What considerations should be given to core returns?

- A. that the unit was originally purchased from you
- B. that the core is in acceptable condition
- C. that it is marked as a core and stored where it belongs
- D. all of the above

64. What is the difference between tubing and hose?

- A. Tubing is not always as flexible as hose.
- B. Tubing size is measured on the outside diameter.
- C. Hose can have reinforcing plies.
- D. all of the above

65. The fuel pressure regulator in an EFI system:

- A. shuts off the fuel pump
- B. maintains a specific amount of fuel in the fuel rail
- C. maintains a specific pressure in the fuel rail
- D. maintains a specific amount of fuel in the intake manifold

66. What is the difference between a halogen and a sealed beam headlight?

- A. nothing
- B. one has a permanent reflectorized surface
- C. the gas used inside the bulb
- D. none of the above.

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

67. What is a short circuit?
- A. a circuit that uses small pieces of wiring
 - B. a powered wire that is grounded before the device it operates
 - C. a powered wire that is grounded after the device it operates
 - D. a low powered circuit
68. Why is it important to maintain a professional appearance personally and in the store?
- A. to gain customer confidence
 - B. It makes you worth more to your employer.
 - C. It improves your standing in the community.
 - D. all of the above
69. Parts Specialist A says an alternator produces AC current that is compatible with the type of current used in the vehicle. Parts Specialist B says an old style generator puts out DC current that is regulated to the vehicle's voltage rating. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
70. What add on sale items might you suggest to a DIY customer buying exhaust parts?
- A. clamps and hangers
 - B. exhaust size adaptors
 - C. exhaust gas recirculation valve
 - D. all of the above
71. A DIY customer had come to you looking for a rebuilt power steering pump. While examining the core you notice that the bearings are destroyed and the pump spins hard. What else might you suggest the customer check?
- A. the drive belt condition
 - B. Make sure the belt is properly tensioned when installed.
 - C. Check for debris and metal shavings in the rest of the system.
 - D. all of the above.
72. A customer is buying replacement pads and rotors for the front brakes on his car. Parts Specialist A has suggested caliper slide lube and anti-squeal compound as well. Parts Specialist B says to also check the caliper itself and to clean the rotor mounting surface. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
73. What does flex fuel or meth-flex refer to?
- A. alcohol based fuel
 - B. synthetic fuel
 - C. nitro methane fuel
 - D. bio diesel
74. A customer is inquiring about a CV-joint boot. Parts Specialist A suggests a rebuilt shaft instead. Parts Specialist B suggests checking the condition of the CV-joint very carefully. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
75. Parts Specialist A has just special ordered a part for a DIY customer for a very old vehicle. He took a deposit on the part and entered a lost sale report as well. Parts Specialist B says this is unnecessary because it is such a slow moving part. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
76. A customer has come to you looking for a tie-rod end for a piece of construction equipment and you have no application listings for it. Where else might you look to find him what he needs?
- A. in an OEM index
 - B. in the illustrated buyer's guide
 - C. in the catalog footnotes
 - D. all of the above

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

77. What does wire gauge refer to?
- A. wire insulation size
 - B. the wires ability to carry current
 - C. wire diameter
 - D. all of the above
78. What function does the MIL light perform?
- A. warns of a brake system failure
 - B. warns of low brake fluid
 - C. tells the driver that the ECM has set a trouble code
 - D. all of the above
79. When a stock order is delivered to your store, what is the first thing that must be done with it?
- A. verify outgoing parts
 - B. rotate the old and new stock
 - C. report any discrepancies between the packing slip and the actual parts received
 - D. none of the above
80. On a special ordered part, what information should be listed on the packing slip before it is turned in?
- A. the part number and price
 - B. the invoice number it was resold on
 - C. any freight or handling charges
 - D. all of the above
81. A customer with an older vehicle has come to you looking for SG grade motor oil, which you don't have. What recommendations can you make that will possibly help him?
- A. Sell him different weight oil.
 - B. Sell him a different grade of oil.
 - C. Explain how the grading system works and suggest higher-grade oil.
 - D. Sell him a non-mineral based oil.
82. A customer who is trying to fit a performance aftermarket muffler with a large inlet to a much smaller pipe, has come to you for help. What information will you need and how do you obtain it?
- A. Ask for year make and model and look up correct pipes for the vehicle.
 - B. Ask the customer to take exact measurements of both the muffler and pipe.
 - C. Ask the customer what brand of muffler it is and explain that your pipes may not fit it.
 - D. all of the above
83. A DIY customer has asked for a recommendation regarding a rust repair and is not concerned about the final finish as long as the vehicle will pass a safety inspection. What type of products might this customer **MOST** likely want?
- A. urethane paint because of it's durability
 - B. lacquer spray paint because of its ease of use
 - C. metal working hammers and a dolly
 - D. fiberglass reinforced fillers, pop rivets and spray paint
84. Why is it important to have inventory in stock that is turned regularly?
- A. so that a profit is returned on stocked merchandise
 - B. so that older parts that don't move as fast can still be stocked
 - C. so that merchandise on display does not get sun faded or shopworn
 - D. all of the above
85. Parts Specialist A has asked a customer for the paint code of a vehicle and has told him to look on the drivers door pillar. Parts Specialist B says it can be found in the VIN number. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
86. A customer who has been quoted a price on a water pump wants to know why it's more expensive than one from the store down the street. Parts Specialist A says it may be because his is new and the other one is a rebuilt unit. Parts Specialist B says that his probably has a longer warranty than the competitors. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

87. A DIY customer asks for an Engine Coolant Temperature (ECT) sensor because an ECT sensor fault code was found with a scan tool. Parts Specialist A says that the old sensor can be checked with a multimeter prior to replacing it to see if that is really the problem. Parts Specialist B says that other factors can cause a sensor failure as well and that any other trouble codes should be checked out as well. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
88. What does it mean to pro-rate a warranty?
- A. to give the customer a better price on the warranty
 - B. to only give a warranty to professional installer customers
 - C. to determine the amount of warranty credit based on length of service
 - D. none of the above
89. When conducting a physical inventory of heater hose, Parts Specialist A finds a new sealed box containing a 25 foot roll and believes he should count it as one unit rather than 25. Parts Specialist B says that he should check to see if the stock keeping unit is by the foot or by the box. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
90. A customer has come into the store looking for brake fluid. His manual recommends using DOT 3 or DOT 4 fluid. Parts Specialist A says that DOT 4 is just a heavy-duty version of DOT 3, with a higher boiling point. Parts Specialist B says that DOT 5 can be used in place of DOT 3 or DOT 4. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
91. Parts Specialist A has been asked for a thermostatic fan switch for a vehicle that has an overheating problem. He has advised the customer to also check the wiring to be certain that power is present at the switch. Parts Specialist B says that the fan clutch may also be at fault. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B
92. A customer you have recently sold brake pads and rotors to has returned complaining of pedal pulsation. What are some of the possible causes for this?
- A. improper installation of the calipers
 - B. improper installation of the rotors
 - C. incorrect parts installed on the vehicle
 - D. all of the above
93. A customer has asked you for a replacement vacuum power brake booster. What other component might have caused the booster to fail?
- A. the vacuum line from the manifold
 - B. the power steering pump
 - C. the master cylinder
 - D. all of the above
94. A customer has requested an O₂ sensor from you to replace one he installed less than a month prior. What might be the cause of this premature failure?
- A. poor quality gasoline
 - B. a leaking head gasket
 - C. the wrong gasket sealer used on the thermostat housing
 - D. all of the above
95. A customer has requested a starter motor for their vehicle. The customer is complaining of hard starting and grinding noises when the starter is engaged. Parts Specialist A says a bad pinion or ring gear can cause this. Parts Specialist B says that it might also be caused by a low battery and poor pinion engagement. Who is right?
- A. Parts Specialist A only
 - B. Parts Specialist B only
 - C. Both A and B
 - D. Neither A or B

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

96. A customer who is changing rear brake shoes on a vehicle without sealed hub/bearing assemblies may also need what other parts to complete the job?

- A. wheel bearings and seals
- B. pinion bearings and seals
- C. brake rotors
- D. all of the above

97. A customer has requested a replacement alternator for their vehicle. What added sales suggestions and advice should a good Parts Specialist recommend with the sale?

- A. Check the condition of the drive belts.
- B. Check the condition of the vehicle's battery.
- C. Check all of the electrical connections at the battery and alternator.
- D. all of the above

98. A customer with a vehicle that only sees summer usage has asked for a replacement battery because the one he bought a year ago is dead. Parts Specialist A says this may be due to the battery going dead over the winter and freezing. Parts Specialist B says it may be due to the alternator not putting out enough to recharge it. Who is right?

- A. Parts Specialist A only
- B. Parts Specialist B only
- C. Both A and B
- D. Neither A or B

99. In the above scenario, assume that the battery had a 65-month warranty with 12 month free replacement, and the customer was given a free replacement after one year. When he returns the following year with the same problem how should his warranty be handled?

- A. Give him another free replacement since this one only lasted a year.
- B. Don't give him anything since he obviously did nothing to correct the problem.
- C. Pro-rate the replacement battery for 2 years.
- D. Sell him a better grade of battery.

100. Which of the following is **MOST** likely to cause an ABS warning light or failure to occur on a vehicle with sealed front hub bearings with integrated sensors?

- A. improperly torqued lug nuts
- B. a bad caliper mount
- C. improper torque of the axle nut
- D. none of the above

101. Parts specialist A is looking for an intermediate exhaust pipe for a pickup truck, and the catalog lists several different lengths depending on the wheel-base. One of the pipes has a notation of "NA" next to it. Specialist A says that this means not applicable to this vehicle, while parts specialist B says this means not available. Which parts specialist is correct?

- A. Parts specialist A only.
- B. Parts specialist B only.
- C. Both parts specialist.
- D. Neither parts specialist.

102. When dealing with a vehicle that was delivered by the manufacturer to a utility body company as a cab on chassis only, what is a good method of determining the vehicles model year?

- A. The VIN number.
- B. The date of manufacture sticker on the door.
- C. The VECI label.
- D. All of the above.

103. Parts specialist A has been trying to locate the correct O2 sensor for a customers vehicle and gotten the wrong one, despite fully understanding all the notations and footnotes pertaining to the listing, and having identified the vehicle with the VIN. Parts specialist A says it's probably due to an incorrect listing in the computer. Parts specialist B says he should have the customer check the VECI label on the car. Who is most correct?

- A. Parts specialist A only.
- B. Parts specialist B only.
- C. Both parts specialists.
- D. Neither parts specialist.

Prepare yourself for ASE testing with these questions on AUTOMOBILE PARTS SPECIALIST

104. A DIY customer has asked you about possible causes for his vehicles check engine light being on and a trouble code indicating an EVAP problem on his pocket code scanner. What should you recommend?

- A. Change the fuel cap, reset the light and see if it happens again.
- B. Take it to a professional for a complete check.
- C. Explain how the system works and ask them to do a physical inspection of all related components, wiring, and hoses before continuing.
- D. Tell him to slowly remove the fuel cap and listen for the sound of escaping pressure in an effort to trace the problem.

105. Parts specialist A is looking for an EVAP canister vent valve, and is not sure what group and sub group to look in his electronic cataloging. Parts specialist A thinks he should look in the paper catalogs table of contents. Parts specialist B says that by switching to alpha mode lookup all he has to do is enter in a description or keyword and he will be directed to the proper area. Who is most correct?

- A. Parts specialist A only
- B. Parts specialist B only.
- C. Both parts specialists.
- D. Neither parts specialist.

Answers to Study-Guide Test Questions

1. **The correct answer is C, both Parts Specialists are right.** Facing merchandise means bringing it to the front of the shelf, which makes the store neater and makes it easier to put new stock behind the old.

2. **The correct answer is B.** Counting the store's inventory determines how much is physically in the store. It is performed to verify financial and other paper records.

3. **The correct answer is D.** There's a bigger markup and the store makes more money on the more expensive upgraded shocks, but with a better product the customer wins, too.

4. **The correct answer is A.** The proper terms are related and seasonal—both items are related to clear vision, and both are seasonal (related to a season, in this case winter) and sold at the appropriate time of year. They might also be impulse items, but 'obligatory' is not a merchandising term.

5. **The correct answer is A.** The reason for a locking case is that the items inside develop 'wanderlust' if you don't watch them. That other customer could be an accomplice, and even big tools can be slipped out quickly if you aren't looking.

6. **The correct answer is D.** A traditional index is typically organized alphabetically.

7. **The correct answer is B.** Different shocks do indeed accompany different engine options; the Parts Specialist probably read this in the parts catalog.

8. **The correct answer is A.** Federal law requires that the VIN number be placed on top of the dash on the driver's side.

9. **The correct answer is A.** An outside micrometer should be used to measure the thickness of a disc brake rotor. Inside micrometers measure the inside diameter of a part; feeler gauges measure the clearance between two parts.

10. **The correct answer is B.** One liter equals 1.057 quarts, so four liters is about four quarts.

11. **The correct answer is D.** The connecting rod converts the linear motion of the piston to the rotary motion of the crankshaft.

12. **The correct answer is B.** Valve seals fit around valve stems to divert excess oil from the valve stems, keeping it from leaking down between the valve stems and guides.

13. **The correct answer is C.** Overhead camshaft engines count camshafts per head, so a DOHC (double overhead camshaft) V6—which has two heads—has four camshafts.

14. **The correct answer is B.** The timing belt should always be replaced after being removed, even if it shows no visible wear. The Parts Specialist should recommend replacement, but remember that it is the customer's choice and that he/she may already have a new timing belt. Failing to recommend the change may or may not bring in extra sales, but should the old timing belt break, it may result in customer ill will.

15. **The correct answer is B.** Sequential fuel injection refers to multiport fuel injection timed to valve opening. Throttle body fuel injection feeds all cylinders simultaneously.

16. **The correct answer is A.** A spark plug that is too hot can cause preignition and damage the engine. A spark plug that is too cold can eventually cause misfiring; this leaves an excess of unburned hydrocarbons, which could cause the catalytic converter to overheat.

17. **The correct answer is D.** The resonator is a secondary muffler in the exhaust system.

18. **The correct answer is B.** The positive crankcase ventilation valve allows crankcase fumes to be burned in the combustion chamber.

Answers to Study-Guide Test Questions

- 19. The correct answer is A.** The oxygen in the injected air combines with unburned hydrocarbons to form water and carbon dioxide. It also combines with carbon monoxide to form less-hazardous carbon dioxide.
- 20. The correct answer is B.** The gears in a manual transmission, and the torque converter and gears in an automatic transmission, exert leverage through the drivetrain, multiplying the twisting force-torque-produced by a vehicle's engine.
- 21. The correct answer is D, the part number index.** This will be at either the front or back of the catalog, and list what page number that part is on. From there you can determine what that number fits.
- 22. The correct answer is C, both Parts Specialists are right.** While almost all front-wheel drive cars do have a transaxle—a transmission and differential combined in a single case—transaxles are also used in rear-engined cars such as the Volkswagen Beetle, mid-engined sports cars such as the Ferrari F40, or even front engine, rear-wheel drive cars such as the 1961 Pontiac Tempest.
- 23. The correct answer is A.** The ring gear circles the flywheel. The starter uses it to turn the crankshaft when the engine is started. Parts Specialist B is wrong because the clutch pressure plate is bolted to the flywheel.
- 24. The correct answer is D.** Leaf springs are flat, usually semi-elliptical springs. Coil springs are wound like a spiral staircase. Torsion bars are flexible steel rods which, when twisted, produce a springing action.
- 25. The correct answer is A.** The pitman arm is connected to a rotating shaft on the steering box. It passes the steering action to the center link. Tie-rods are attached to either end of the center link.
- 26. The correct answer is C.** Diodes permit current flow in one direction; they are not intended as circuit protection.
- 27. The correct answer is A.** Also called sheet metal screws, self-tapping screws create their own threads in the sheet metal parts they hold together.
- 28. The correct answer is C, both Parts Specialists are right.** The MAP sensor and Barometric Pressure sensor can look exactly alike on some models. They perform the same basic function of providing a pressure reading to the computer. The MAP sensor provides a pressure reading inside the intake manifold, while the BP sensor provides the barometric pressure reading. The computer uses this information to regulate fuel mixture and ignition timing, as well as other emission control functions.
- 29. The correct answer is B.** The condition of the vacuum hoses around the intake manifold should be considered. None of the other items listed will have a direct affect on the MAP sensor.
- 30. The correct answer is A.** Belt pitch refers to the spacing between grooves on a Micro V-belt. Belt diameter around the pulleys could be thought of as length but it is never expressed that way.
- 31. The correct answer is C.** The part shown is the clutch disc. The pressure plate and throw-out bearing should always be replaced along with the clutch disc. The flywheel should also be checked for runout and surface condition. A flywheel or pressure plate that is not in good condition will dramatically shorten the life of a clutch disc.
- 32. The correct answer is B.** The parts shown are the rear components of an alternator assembly. On many alternators, the voltage regulator is located inside the alternator.
- 33. The correct answer is C.** Open the box and verify that the part is new. Use the buyer's guide or other means such as casting numbers and size charts to determine that it is the correct part before shipping it to the customer.

Answers to Study-Guide Test Questions

34. **The correct answer is B.** The part shown is the harmonic balancer (crankshaft damper) with CKP sensor interrupter rings attached, for a General Motors 3800 engine with C3I ignition system.

35. **The correct answer is D, neither Parts Specialist is right.** A radiator cap valve opens to allow coolant from the recovery tank to return to the cooling system to prevent hoses from collapsing when vacuum is created. The correct sale for this problem would be a new radiator cap.

36. **The correct answer is D, neither Parts Specialist is right.** The thermostat's function is to help the engine reach normal operating temperature as quickly as possible. Only a thermostat rated for the correct heat range should be installed, because the engine computer bases fuel mixture, ignition timing, EGR operation and other functions on coolant temperature. If the thermostat is good and the engine runs hot, a different problem exists.

37. **The correct answer is D.** Multiply the cost by 1.43. If the cost of \$5.25 is multiplied by .30 the result is 1.575, and when this is added to 5.25 the sum is 6.825. Thirty percent of 6.825 is 2.04, and when this is subtracted from 6.825 the result is 4.785. Since this is less than the \$5.25 that was paid for the part, you have not made a 30% profit on your investment.

38. **The correct answer is C.** A Material Safety Data sheet is used to identify the proper handling procedures for the material it is assigned to.

39. **The correct answer is D.** All of the reasons listed could be the cause. This is why good housekeeping and accurate invoicing are essential to keeping an accurate inventory.

40. **The correct answer is C.** He should make his case with management. It does no good to complain to somebody who can't do anything about it, nor do you want to give customers a bad impression of you or your store.

41. **The correct answer is B.** Make sure the catalog and computer agree on the part number first. If they agree, then you can look for other reasons, such as incorrect vehicle ID or boxing.

42. **The correct answer is B.** A dial-indicating caliper for measuring from 0 to 6 inches would see the most use behind a parts counter. A dial indicator and a digital micrometer are more commonly found in a machine shop and a caliper-resetting tool is used in brake work.

43. **The correct answer is C.** Ask them how they would like to handle the situation. Since you obviously can't complete the sale and their personal finances are none of your business, this is the only decent option you have.

44. **The correct answer is C, both Parts Specialists are right.** The engine size can be determined from both identifiers.

45. **The correct answer is D.** All of the items mentioned should be checked to find out where the brake fluid went and what damage it may have caused. Fluid leaking into a power booster or on to brake linings can cause both to fail.

46. **The correct answer is B.** Explain what is involved and what will be needed and let the customer decide. Answer A is partially right in that a good service manual should be one of the special tools suggested.

47. **The correct answer is D, none of the listed responses was correct.** You have to know what brand and grade of pad the other store was selling before you can compare. You should also never speak badly about your competition's parts or service, but explain why yours is better.

48. **The correct answer is B.** A tag number refers to a tag placed directly on the part. The SPID label may contain this information also but the catalog was asking for a number off the part itself.

Answers to Study-Guide Test Questions

- 49. The correct answer is B.** Although the original invoice may or may not be required by the manufacturer, the pro-rate fee always reverts to the original date of purchase, not to the end of the free replacement period.
- 50. The correct answer is A.** The number of lines on a bolt head indicate grade; the more lines, the higher the grade.
- 51. The correct answer is D.** Act calmly and determine what needs to be done. Engaging in a shouting match with a customer will not do either one of you any good, nor will ignoring his problem make it go away.
- 52. The correct answer is A.** Explain that the person is new and that you are working with them. You may not always be available when he calls, so at some point the customer will have to deal with somebody else. If it is a recurring problem, then management should be made aware of it but never ignore the customer's complaints.
- 53. The correct answer is C.** Inventory movement is gauged in turns, or how many times an item is sold in a set amount of time.
- 54. The correct answer is D, none of the listed responses was correct.** You should take customers, both phone and walk-ins, in the order in which they arrived. Always acknowledge a new customer and assure them that they will be waited on, but don't try to split your attention or help two at once.
- 55. The correct answer is D.** All of the listed answers can cause damage to an ECM unit, even the static discharge from someone touching the pin connectors. Proper ECM operation can also depend on whether other systems and components are in good condition.
- 56. The correct answer is B.** Shock absorbers alone will not increase the vehicle's ability to carry more weight. Spring capacity must be added.
- 57. The correct answer is C.** An OBD II scan tool is used for trouble code retrieval from an on-board diagnostic system.
- 58. The correct answer is A.** The type and condition of the finish on the vehicle, as well as the customer's desires, will determine what is best to use.
- 59. The correct answer is B.** A proportioning valve limits the hydraulic pressure going to a wheel, while a metering valve affects the timing of pressure delivery.
- 60. The correct answer is A.** Rack-and-pinion is often found on front-wheel drive vehicles with strut type suspension, while the recirculating ball or 'conventional' type is found on rear-wheel drive vehicles with A arm suspension. Kingpins and ball joints are parts used to attach a steering knuckle to the axle or A arms.
- 61. The correct answer is B, to verify the price when the part was sold.** Even if you are absolutely certain that a part came from your store and the reason for return is legitimate, you need to know the selling price.
- 62. The correct answer is D.** It is a compression fitting. It is named for the compression collar used on the tubing.
- 63. The correct answer is D, all of the reasons listed.** Care should be taken to make sure the core is acceptable to the rebuilder and that it does not get mixed in with warranty returns.
- 64. The correct answer is D, all of the statements are true regarding hose and tubing.**
- 65. The correct answer is C.** The pressure regulator maintains a specific pressure in the fuel rail so that the injectors have enough fuel to operate at all engine speeds.
- 66. The correct answer is D, none of the statements are entirely correct.** A halogen bulb does use a different gas than an incandescent bulb, but both can be sealed beam lights.
- 67. The correct answer is B, a powered wire that is grounded before the device it operates.** In a DC system, the wire after the powered unit must run to ground in order to complete the circuit.

Answers to Study-Guide Test Questions

68. The correct answer is A, to gain customer confidence. While all of the statements are essentially true, only the first one applies in the context of sales skills.

69. The correct answer is B. An alternator produces AC current, which must be converted to DC by the rectifier or diode assembly in order to be used in the vehicle.

70. The correct answer is A, clamps and hangers. Size adaptors may be needed if the system is non-standard or otherwise altered, but the customer will have to tell you this and also what size he needs to adapt to.

71. The correct answer is D, all of the things listed should be checked before putting the vehicle back in service. An overly tight V-belt can destroy the belt and put enough strain on the pump bearings to cause it to fail. A pump that is run with a bad shaft bearing could possibly start to grind itself up inside and spread debris throughout the system.

72. The correct answer is C, both Parts Specialists are right. Pad squeal can be prevented with the use of anti-squeal compound applied to the back of the pad. Poor caliper condition and improper rotor mounting will have a direct effect on pad life and pedal pulsation.

73. The correct answer is A, fuel made up of a mixture of gasoline and methanol alcohol. Bio diesel is a blend of petroleum based and soybean oil. Nitro methane is a racing fuel only.

74. The correct answer is C, both Parts Specialists are right. The condition of the joint should be carefully looked at and the shaft replaced if it is questionable. Many professional installers will automatically replace the shaft rather than replace the boot because they have no idea how long it has been torn, allowing water and dirt into the joint.

75. The correct answer is A. A lost sale report should be done no matter what the part is. Any item not on the shelf when the customer asks for it is considered a lost sale, even if you get the order.

76. The correct answer is B, in the illustrated buyer's guide. By measuring the old part you may be able to match it to one listed in the buyer's guide size charts, even though it is not listed by application.

77. The correct answer is C. Wire diameter has a direct bearing on how much current it can carry but wire gauge is used to identify the diameter.

78. The correct answer is C. The MIL, or Check Engine light, warns the driver that a problem has arisen in the engine control system and a trouble code has been stored in the ECM.

79. The correct answer is C. Check the packing slip against what you received and report any discrepancies.

80. The correct answer is D, all of the items listed should be on the packing slip. You will need to know your cost so you can mark it up to the desired level, and the bookkeeper will need to know when it was resold and any additional charges associated with it.

81. The correct answer is C. Explain the differences in the oil grades and that according to API specifications, a higher-grade oil may be substituted for a lesser grade.

82. The correct answer is B. Have the customer take exact measurements of the pipe and muffler. Year make and model as well as brand of exhaust parts are seldom of any use when customizing in this manner.

83. The correct answer is D. If the customer has expressed a desire to simply fix a rust hole these are the materials that he would most likely need. Hammers and dollies are used to straighten metal panels, and while paint type may not even come up the customer is obviously looking to get out of the repair as cheaply as possible.

84. The correct answer is A. A part that sits on the shelf not only doesn't make a profit, it also costs money due to the carrying cost of having it there.

Answers to Study-Guide Test Questions

- 85. The correct answer is A.** While the paint codes and factory options can be found by entering the VIN in an OEM database, the code itself is not contained within the VIN.
- 86. The correct answer is D, neither Parts Specialist is right.** Although they both may be correct in their assumptions, until they know for sure what the competition sells, they are just guessing.
- 87. The correct answer is C, both Parts Specialists are right.** Before replacing any suspected electronic part such as a sensor, it is a good idea to find out if the old one is really bad. It's also a good idea to find the reason why a part failed before the replacement ends up bad as well.
- 88. The correct answer is C.** Pro-rate means to determine the warranty amount based on how long the part was in service. This is usually done on life limited parts such as batteries, rather than give a full warranty.
- 89. The correct answer is B.** When dealing with bulk packaged products, you should always be aware of how they are inventoried and billed.
- 90. The correct answer is A.** DOT 3 and DOT 4 are mineral based and can be safely mixed together, but DOT 5 is silicone based and will not mix. In order to use DOT 5 in a vehicle that has had DOT 3 or DOT 4 installed, the entire system must be flushed first.
- 91. The correct answer is A.** A vehicle that uses an electric fan, as evidenced by the fact that the customer needs a switch, does not use a fan clutch.
- 92. The correct answer is D, all are possible causes.** All aspects of pad, rotor and caliper installation must be done properly or pulsation can result. Calipers that are cocked in the slides and allow the pad to hit on an angle, and rotors that are not perfectly flat to the hub because of corrosion will cause pulsation. It's also possible that the wrong parts have been installed, causing pad binding or improperly seated rotors.
- 93. The correct answer is C.** A leaking seal in the back of the master cylinder can allow brake fluid into the booster, which can destroy the diaphragm. While a bad vacuum hose can cause loss of brake boost it can't damage the booster, and unless it is a hydroboost system, not vacuum, the steering pump has no bearing on braking.
- 94. The correct answer is B.** Anti-freeze leaking into the combustion chamber can cause an O2 sensor to fail. The use of leaded fuel can also poison an O2 sensor but low octane ratings should have no effect. Fumes from gasket sealers are only a problem if they can enter the exhaust stream, such as when used on intake or exhaust manifolds.
- 95. The correct answer is C, both Parts Specialists are right.** A starter motor requires both sufficient voltage and amperage to crank the engine, and proper pinion engagement. If either one is not right problems can occur. The condition of both the pinion and the ring gear need to be examined and the starter needs to be positioned so that the pinion has proper clearance on the ring gear if it's adjustable with shims.
- 96. The correct answer is A.** Since the wheel bearings must be disturbed to gain access to the brakes it's wise to check their condition and replace if necessary, and wheel seals should never be reused even if the bearings are not replaced. Pinion bearings and seals are inside the differential housing and are not part of the wheel end/brake assembly, and rotors are not used on drum brakes.
- 97. The correct answer is D, all of the items listed should be checked.** An alternator requires sufficient power from the battery to operate, and while it may work with a low battery it can overload and suffer rapid failure. Alternators and batteries also require clean tight connections to operate at peak efficiency, and the drive belt should always be checked when it is removed for alternator service.
- 98. The correct answer is A.** If the vehicle was stored with no attention paid to the battery it is quite possible that the battery lost enough charge for the electrolyte to freeze and ruin the battery. If the battery was in good shape when it was stored the alternator would really have no bearing on battery condition aside from parasitic drain, so poor alternator output is not the answer.

Answers to Study-Guide Test Questions

99. The correct answer is C. The original battery came with a 12 month free replacement, which was done in the first 12 months of ownership. At that point any further warranty claims must revert back to the date of the original battery purchase, not to when the free replacement was given.

100. The correct answer is C. If the axle nut is not torqued to correct specifications it may allow the bearing to run too loose or too tight, which can lead to damage of the integrated ABS sensor. While it's not impossible for the caliper mounts or lug nuts to have an effect on ABS, it is more likely to cause brake pulsation.

101. The correct answer at this point is D, neither parts specialist is correct until the meaning of the "NA" notation is verified in the catalog. Assuming the meaning gives you a 50% chance of getting the wrong part, or telling the customer that you can't provide something that you may in fact have.

102. The correct answer is A, the VIN number. While any of the other answer options may be correct, they may not even be present on the vehicle, or not applicable to that vehicle as sold by the utility body company.

103. The correct answer is B, parts specialist B only. While it's not impossible to find incorrect listings in either the paper or electronic listings, never assume that's the case until every other bit of vehicle information is checked. In this case the VECI may reveal that the car has California emission controls even though it was not sold there, and this made the difference between the right and wrong part.

104. The correct answer is C, do a physical inspection of all components before replacing parts or taking it to someone else. It may be a simple matter, or it may be something beyond the abilities of a DIY customer to fix, but it's their decision to make.

105. The correct answer is B, parts specialist B only. Looking in the paper catalog contents or index pages will get you where you need to go in the catalog, but may not correlate to the electronic cataloging. It's important to remember that the part supplier provides the information contained in the computer cataloging, but the programming and layout is their own design, so it's important to know how to use both.

Notes

107. The correct answer is B. Four vehicles B only. While it's not impossible that incorrect data in the paper or electronic database, most cases that the car will not, either for of vehicle information is checked. In this case the VECI may reveal that the car California emission records even though it was not sold there, and this might be the difference between the right and wrong part.

108. The correct answer is C. On a physical inspection of all components before repair of parts or timing it is common case it may be a simple repair or it may be something beyond the ability of a DIY customer to do. But it's a risk decision to make.

109. The correct answer is B. Four vehicles B only. Looking in the paper catalog contains a index page with car, year, make, and model in the catalog that may not correlate to the electronic catalog. It's the owner or technician's job the part supplier provides the information contained in the catalog, especially for the programming and layout is that can depend on its importance to know how to use part.

110. The correct answer is C. The original battery code with a 12 month warranty period, which was made in the first 12 months of ownership. At that point any further warranty claims were traced back to the date of the original battery purchase, not to when the first replacement was made.

111. The correct answer is C. If the axle nut is not torqued to correct specifications it may allow the bearing to run too loose or too tight, which can lead to damage of the bearing and axle wear. While a nut that is loose for the right amount of lug nuts to have an effect on ABS, it is more likely to cause brake pulsation.

112. The correct answer is D. Neither. Four-point contact with the bearing is the main reason a wheel is worked to the center. Assuming the main bearing has a 30% chance of failing the wrong gear, including the customer, the car can't provide some data that you can't see here.

113. The correct answer is A. The VIN number. While any of the other answer choices may be correct, they may not even be present on the vehicle or the vehicle's title to the vehicle itself by the manufacturer's name.

Glossary of Terms

--a--

ABS - abbreviation for anti-lock brakes. A system designed to keep a vehicle's wheels from locking up and skidding under hard braking.

aftermarket - parts or components manufactured by companies other than the original equipment manufacturer. Also known as imitation, bootleg, knock-offs (see OEM).

air bag/air cell - a rubber air chamber used in place of a conventional leaf or coil spring in a suspension system.

air filter - a device to clear dust and dirt from the air before it is drawn into the engine.

alkaline base (cleaner) - a form of chemical cleaner used in parts cleaning; includes most soaps and detergents, as well as resin-, silicate-, and phosphate-based cleaners. Most work best when heated to temperatures of 180°F or above.

alternating current (AC) - electrical current that flows 'back-and-forth,' rather than in one direction (i.e., from positive to negative, then from negative to positive).

alternator - rotates a magnetic field coil (energized by battery current) inside stationary stator (output) windings, producing alternating current. The alternating current is then internally rectified via diodes to DC or direct current.

ammeter - an instrument used to measure the amount of current flow within a circuit.

ampere hour - an outmoded method of rating a battery's capacity to provide current over an extended period of time (see reserve capacity).

Anti-lock Braking System (ABS) - ABS works by sensing wheel lockup and dropping (or modulating) the pressure to the brakes, preventing skidding and allowing the driver to maintain control of the vehicle. Tests have shown that ABS decreases the distance needed to bring a vehicle to a stop, hopefully allowing someone to avoid a collision.

axle ratio - the ratio between the rotational speed (rpm) of the driveshaft and that of the driven wheel. Gear reduction in final drive is determined by dividing the number of teeth on the ring gear by the number of teeth on the pinion gear.

--b--

backing plate - the plate that drum type brake shoes and wheel cylinders mount to.

ball joint - a flexible joint consisting of a ball within a socket. Ball joints act as pivots, which allow turning of the front wheels and compensate for changes in the wheel and steering geometry that occurs while driving.

bearing - a bearing is a special, replaceable insert composed of several layers of such metals as lead, tin and antimony. These metals are capable of withstanding high loads and wearing for a long time, provided that they remain coated with a thin layer of oil under pressure. Examples are the main and connecting rod bearings of an engine. These bearings are formed of two half-circle sections, which are assembled together to form a complete circular bearing.

bias-ply tires - bias-ply tires employ belts that run diagonally across each other. The belt leaves the bead on one side and runs to the opposite bead on an angle.

blue drum - a brake drum whose friction surface has 'blued' from high temperature. For example, high temperatures may result from dragging brakes caused by weak return springs.

booster or brake booster - used to amplify or boost the pressure applied to the brake master cylinder by the application of the brake pedal.

brake block - the friction material or lining that is attached to the brake shoe. Disc brakes use pads with friction material.

brake master cylinder - a cylinder containing a movable piston activated by pressure on the brake pedal. The piston produces hydraulic pressure that pushes fluid through the lines and wheel cylinders/calipers. This forces the brake lining or pad against the drum or disc to slow or stop the vehicle.

Glossary of Terms

broadcast sheet - also called a line sheet, this is a 'birth certificate' of sorts for GM medium-duty vehicles. It will list all of the major and minor assemblies used at the time of manufacture. Similar in use to a SPID label.

brush - a piece of conducting material. When it is placed against a commutator, slip ring, etc., it will provide a passage for electrical current.

bumper reinforcement - the mounting for the bumper fascia, which is a flexible plastic covering for the front or rear of the vehicle. The fascia can absorb impacts from road debris and minor collisions without showing damage.

burnish - to condition or 'season' a brake lining by wear and temperature, by way of a test procedure or in-service operation.

--C--

C.F.M. - abbreviation for cubic feet per minute. A measure of a compressor's output.

caliper - when used in a brake system, this is a hydraulic cylinder used to push the brake pads against the rotors. Also the name of a measuring device with one sliding and one fixed jaw, that is capable of measuring down to the thousandths of an inch.

cam lobe - a raised portion on a camshaft, which imparts motion to another part resting on it.

camshaft - a shaft with cam lobes that, via the valve-train, opens the valves.

captive item - a part only available through OEM dealerships.

carburetor - a device used for mixing fuel with air for combustion in a gasoline engine.

carrying cost - the cost of having inventory, including floor space and storage, insurance, taxes, interest, and obsolescence and depreciation.

center bearing - a driveshaft part that is used when a driveshaft is divided into sections. The center bearing is used as a support in the area where there are two sections being joined.

charts - catalog shortcuts, which will list items specific to only one minor group or system, such as tune-up parts or trim items.

chlorofluorocarbon - a chemical compound containing chlorine and fluorine; considered harmful to the earth's ozone layer.

circuit breaker - uses a heat sensitive spring to break electrical contact in an overload condition. Automotive circuit breakers, unlike household circuit breakers, will reset automatically to close the circuit when they cool off.

clips and hardware - those hardware items used to attach moldings, trim and body parts to the vehicle. Some hardware items are listed in estimating guides as parts and may be included in the appraisal as line items.

clutch release bearing - a ball bearing that allows the stationary clutch fork and coupler to draw or push the spinning clutch pressure plate away from the flywheel.

combustion chamber - the area inside the cylinder head in which the air/fuel mixture is burned.

compression fittings - connectors that compress a sleeve onto tubing to hold it.

compressor - in an air conditioning system, the part that compresses the refrigerant before it is cooled and then allowed to expand, cooling it further.

condenser - in an air conditioning system, where the compressed refrigerant is cooled before being allowed to expand.

connecting rod - engine part that links the piston and crankshaft.

constant velocity joint - any of the universal joints that are designed so that the speed fluctuation of the simple universal joint does not occur.

core - part exchanged for rebuilt part when the latter is purchased (providing a rebuilder's 'raw material' reduces the buyer's cost).

cotter pin - a locking device for special nuts and bolts, or used to secure linkage.

Glossary of Terms

crankcase - the area within the engine surrounding the crankshaft, including the sump.

crankshaft - a shaft with offset sections to which the big ends of connecting rods are attached; transfers reciprocating motion of the piston to circular motion.

CV-joint - abbreviation for constant velocity joint.

cylinder head - the removable casting that covers the top of the cylinders. Combustion chambers are cast into the cylinder head and these form the roof of the cylinder. One cylinder head resides on each bank of the engine block. The cylinder head also contains the intake and exhaust ports, valve guides and valve seats, and mounting points for the valvetrain and spark plugs or diesel injectors.

cylinder liner - a replaceable liner that can be pressed into a cylinder block bore. There are two types of liners, dry and wet. Each liner is installed differently and they are not interchangeable.

--d--

desiccant - a medium used within an air dryer cartridge that traps moisture droplets.

diode - a semiconductor device that allows current to flow in one direction only, used with an alternator to create direct current.

direct injection - said of a combustion chamber that receives fuel directly from the injector and handles the entire combustion process. Direct injection diesels are efficient because there is relatively no air movement in the chamber, which reduces the amount of heat the cooling system has to carry away.

distributor-type injection pump - a pump used primarily in medium and light duty trucks. The distributor-type pump uses a single central plunger, which is driven via a cam plate, for fuel pressure generation and distribution to individual engine cylinders. A control sleeve is used to meter the quantity of fuel that is injected.

DIY - short for Do-it-Yourself: a non-professional installer who repairs his own vehicle.

DOHC - abbreviation for double overhead cam.

door handles, latches and striker bolt assemblies - door lock and handle assemblies usually consist of the outside door handle and linkage, the inside handle, the inside locking rod and the locking mechanism. There are several types of exterior door handles available. On the push-button type, the button presses directly on the lock mechanism to open the door. Another more common type is the lift handle type. When the handle is lifted, one or more linking rods operate the lock mechanism.

drag link - an arm that runs from the steering box to the steering arm on the knuckle assembly. It is used to transmit motion from the box to the knuckle.

draw (amperage) - the amount of current needed to operate an electrical device.

--e--

ECM/PCM - short for Engine Control Module and Powertrain Control Module.

EFI - abbreviation for electronic fuel injection.

electrolyte - the fluid medium of a lead-acid battery; electrolyte contains sulfuric acid, which can cause severe chemical burns.

Electronic Control Module (ECM) - a preprogrammed microprocessor that regulates engine fuel injection, ignition timing, and possibly other functions.

energy absorbers - help the bumper system absorb the energy in a minor impact. An energy absorber can be either a piston style hydraulic or gas-charged device located between the front frame rails and the bumper reinforcement or face bar. They may also be an accordion type metal bracket that, once damaged, must be replaced.

engine block - the main body of the engine; the part that contains the cylinders.

evaporator - in an air conditioning system, the 'radiator' through which chilled refrigerant flows and over which the air entering the interior is cooled.

exhaust valve - valve that opens to allow burnt air/fuel mixture to escape from a combustion chamber.

Glossary of Terms

expansion valve - in an air conditioning system, it regulates the amount of refrigerant allowed into the evaporator, thus controlling interior cooling.

--f--

fascia - the part of a bumper assembly that covers the energy and load bearing components of the assembly. The fascia is not crucial to the safe operation of the vehicle and is usually designed for cosmetic applications.

fixed glass - 'immovable' glass, which cannot be opened (e.g., windshields, back windows).

flare fittings - connectors designed to be used with flared tubing.

fuel injection - a system that sprays fuel into the air intake stream.

fuel pump - a device to transfer fuel from the fuel tank to the carburetor or fuel injection system; may be mechanical (engine-driven) or electric.

full frame - also known as perimeter frame, the full frame design has faded from use in passenger cars today. However, the resurgence of light trucks and sport-utilities in the market has caused the full frame design to reappear in repair shops. In the full frame design, the body is a separate unit mounted on the frame.

function - the performance and operation of a part or assembly.

fuse - a replaceable electrical failsafe designed to 'burn out' to prevent excess current flow.

fusible link - a section of wire with fewer strands of wire (smaller gauge) than the rest of the circuit. It is designed to 'burn out' or melt in order to prevent excess current flow from damaging the circuit.

--g--

glass setting tape - used on some lift channels or sashes to hold the glass in place. This tape may be of a cloth type or a rubber material. A piece of tape the length of the channel is cut from the roll.

glow plug - an electrically heated device used in a diesel engine. It preheats the combustion chamber to aid in cold starting.

gondola - shelf rack system on which goods are displayed for purchase.

group number - a number assigned to a major system of a GM vehicle, which covers every component within that system. Groups are broken down into major, minor and sub designations for every part number.

GVW - Gross Vehicle Weight; the total weight-carrying capacity of one vehicle.

--h--

handling charge - any special costs over and above the cost of a part for freight or return fees.

hardware kit - a kit containing all of the return springs and other necessary items, such as rollers or hold-down pins used on a drum brake assembly. In the case of disc brakes, it might contain pins, sliders or retainers, as needed.

head - see cylinder head.

head gasket - sealing material between engine block and cylinder head.

heat range - refers to the ability of a spark plug to dissipate combustion heat to the cylinder head, reflected in its operating temperature.

hydrometer - an instrument with a float housed in a glass tube that measures the specific gravity of a liquid.

--i--

identification tag - see trim tag.

ignition coil - a device that raises battery voltage to a point sufficient to fire the spark plugs and ignite fuel; usually called a 'coil'.

impulse items - items that the buyer had not planned to purchase.

Glossary of Terms

inboard/outboard mount - a way of expressing whether a drum or rotor is mounted to the inside or the outside of the wheel hub.

intake manifold - passageways, usually cast in aluminum or cast iron, that carry air or an air/fuel mixture to the intake ports in the head.

intake valve - a valve in the intake port that opens to allow the air/fuel mixture to enter the combustion chamber.

integral power steering - a unit designed with the vehicle. It typically incorporates a hydraulic pump and a steering gear where the pump's hydraulic fluid directly puts pressure on and helps actuate the mechanical parts in doing the work of steering the vehicle.

inventory - a store's sales stock or its dollar value (see physical inventory).

inventory system - a set of procedures to keep track of stock quantities.

--j--

jobber - a business that sells to bulk or commercial users; a wholesaler.

--k--

keyless entry systems - utilize a keypad on the outside panel of the driver's door. A preset series of numbers are punched in and the door unlocks. Also available are systems that allow the driver to unlock the car door from a distance, without ever touching the vehicle. In this case, the key chain has a low frequency transmitter, which causes the doors to unlock when the key chain comes within range. The system will also automatically lock the doors when the key chain moves more than a given distance from the vehicle. Check the service manual before working on these systems.

kingpin - the pin used to attach the steering knuckle to the axle casting and allow the knuckle to move freely.

--l--

leaf spring - a suspension spring consisting of a single or multi-layered strips of spring steel held together with a center bolt.

lining - the friction material on the brake shoes.

lockwasher - any of several special washers that keep a fastener from loosening.

lost sale report - a form filled out whenever a sale is not made because of out-of-stock, non-carried items, etc.

--m--

MacPherson strut suspension - a suspension system wherein the strut assembly forms a single unit, which replaces the coil spring, shock absorber and upper control arm found in SLA systems. The strut-type suspension has gained wide acceptance because of its lighter weight.

master cylinder - a hydraulic cylinder activated by foot pressure from the driver and used to send hydraulic pressure to wheel cylinders or calipers.

metering valve - used to delay hydraulic pressure to the front brakes until the rear brakes have had time to apply. Found on disc/drum combination systems.

MIL - Malfunction Indicator Light, also known as the check engine light.

--o--

OEM - Original Equipment Manufacturer (as opposed to an aftermarket manufacturer).

OHC - abbreviation for overhead cam.

OHV - abbreviation for overhead valvetrain (see pushrod engine). Common name for engines that have the camshaft located in the engine block. This type of valvetrain uses pushrods to actuate the valves.

outer body panels - refer to those panels that form the exterior of the vehicle. These panels may be bolted on, as in the case of fenders, hoods, and deck lids, or they may be welded or bonded on, such as quarter panels and door skins.

Glossary of Terms

overhead cam engine - an engine that has one or two camshafts located in the head. This type of engine doesn't use pushrods. The valves are actuated directly by the camshaft lobes or valve lifters.

--p--

PARTECH - a service offered to GM parts dealers for assistance with part identification.

PCV valve - Positive Crankcase Ventilation valve. A valve that allows intake manifold vacuum to draw off crankcase fumes for burning in the combustion chamber.

PDC - short for parts distribution center, or GM parts warehouse.

physical inventory - a counting of a store's inventory for accounting and/or tax purposes.

pipe fittings - connectors designed with tapered threads for use with threaded tubing.

piston - a cylindrical object which fits in a cylinder for imparting or receiving force; in an engine, the part that is forced downward by the expansion forces of burning fuel.

piston pin - rod that passes through the piston and connecting rod to secure one to the other; also called wrist pin.

piston rings - special metal rings placed in a groove around a piston to prevent compression leakage (compression ring) or excessive oil consumption (oil control ring).

PO - short for Purchase Order. Authorization or documentation of parts or services provided by an outside source.

pressure plate - a smooth-faced metal disc used to clamp the clutch disc against the clutch face of the flywheel.

production tag number - a number assigned to a part or assembly at the time of manufacture. This is not the same as a service replacement part number and an interchange chart may be required to cross-reference it.

proportioning valve - used to limit the amount of pressure to the rear brakes to keep them from locking up before the front brakes.

pushrod - a rod which, as part of the valvetrain, transmits motion from valve lifter to the rocker arm.

pushrod engine - engine with the camshaft in the engine block, requiring pushrods as a part of the valvetrain.

pyrolytic oven cleaning - a cleaning process that uses heat. Parts are baked at 400-800°F, causing deposits to harden and flake off or to burn off.

--r--

radial-ply tires - radial tires have belts or cords that run from bead to bead directly along the radius of the tire. This maximizes the tread's contact with the road. By enabling the casing to flex more easily, fuel economy is maximized and heat minimized.

radiator - a network of tubes and fins through which hot coolant flows for heat dissipation.

radiator cap - a sealed 'lid' for the cooling system, vented with a pressure relief valve.

RAPID - an inventory tracking and ordering system for GM dealerships.

related items - items used together or likely to be purchased at the same time.

reserve capacity (RC) - the number of minutes that a battery can deliver 25 amps at 80°F (1.75 volts per cell). To estimate the ampere hours at the 20-hour discharge rate, multiply the reserve capacity rating by 0.6. To estimate the reserve capacity, divide the ampere hour rating by 0.6.

retail - sales to the general public.

return springs - springs which retract the brake shoes upon release of the brake pedal.

rocker arm - a part of the valvetrain that moves in a rocking motion, imparting motion from the camshaft to the valve.

RPO code - short for Regular Production Option. This is a three-character code assigned to parts and systems at the time of manufacture used to identify them when looking for replacements.

Glossary of Terms

--s--

SAE - acronym for Society of Automotive Engineers. An organization that, among other things, establishes standards for automotive engineering.

safety stock - that part of inventory that guards against outages in the working stock.

scored drum - a brake drum with a grooved friction surface.

seasonal items - items likely to be bought in greater quantities at specific times of the year.

shock absorber - a hydraulic or gas filled cylinder and piston used to dampen suspension movement.

SOHC - abbreviation for single overhead cam.

SPAC - short for Service Parts Assistance Center. A service of GM service parts organization for tracking parts orders and order status as well as locating items not in any PDC.

spark plug - a device for igniting the air/fuel mixture in the combustion chamber on a gasoline engine.

speed sensor/ABS - an electromagnetic device that, in conjunction with a rotating toothed wheel, generates an electrical signal proportional to wheel speed and transmits the information to the ABS electronic control unit.

SPID label - short for Service Parts Identification Label. This is a document attached to the vehicle listing all of the RPO codes for parts used at the time of manufacture.

spring hanger - an attaching point on the frame for holding one end of a leaf spring.

spring shackle - an H shaped part used to connect the free end of a leaf spring to the frame and still allow lengthening of the spring under compression.

steering knuckle - the suspension component that connects the upper and lower control arms or the strut and lower control arm. On rear-wheel drive vehicles, it usually incorporates the front wheel spindle and on front-wheel drive vehicles, it has an opening where the half-shaft passes through. A steering arm is attached to the steering knuckle, where the tie-rod end is connected.

stock rotation - procedures to ensure that the stock first in is the first sold.

stud - threaded fastener with threads on both ends; one end turns into a threaded hole in a part, the other passes through another part, which is held to the first part by a nut.

synchronizer - a device that eases transmission shifting and ultimately locks transmission gears to a shaft. When a driver attempts to engage the next transmission gear, synchronizer metal clutches bring the gear and shaft to approximately the same speed utilizing friction. Once the shaft and gear are rotating at the same speed, a blocking mechanism that prevented engagement releases and allows rings or shift collars to lock the gear to the shaft.

--t--

TBI - abbreviation for throttle body injection.

thermostat - in a cooling system, the valve that allows coolant to flow through the radiator when the coolant reaches a preset temperature.

throttle body injection (TBI) - a lower-cost fuel injection on gasoline engines with injectors located in a carburetor-like body on the intake manifold.

tie-rod - steering linkage member that connects the steering knuckle arm with the center link or the steering rack.

timing gears - gears connecting the crankshaft to the camshaft(s), located inside the engine.

tone ring - a toothed steel ring that passes in front of an ABS wheel speed sensor, which sends a signal to the ABS module.

track arm or radius rod - a rod used to locate and anchor an axle in the lateral plane.

trim tag - a manufacturer's tag that carries paint codes, optional equipment numbers and similar information.

--u--

U-bolt - a U shaped bolt used for attaching the springs to the axle assembly.

Glossary of Terms

unibody - a vehicle design in which the frame and structural members are integrated into a single unit.

universal joint - any of several devices that allow a shaft to pivot in any direction.

USS - abbreviation for United States Standard. An organization that establishes industry standards, such as thread types and sizes, for industrial use in the U.S.

--v--

valve - opens and closes the intake and exhaust ports in the cylinder head.

valve guide - a special metal insert in the cylinder head through which the valve stem passes.

valve keeper - with the valve retainer, holds the valve spring on the valve stem.

valve lash - it is best defined as empty space in an engine's valvetrain. The engine's valvetrain incorporates an adjustment that enables a technician to put lash, or empty space, into the system. This lash ensures that the valves will seat securely under all operating conditions by allowing for possible variable contraction and expansion in parts due to temperature changes.

valve retainer - with valve keepers, holds the valve spring on the valve stem.

valve seal - any of several types of devices that keep excess lubricating oil from traveling down the valve stem into the valve guide.

valve seat - face area against which the valve closes.

valve spring - a spring that holds the valve closed.

valve stem - the cylindrical part of the valve that extends through the cylinder head.

valvetrain - collection of parts connecting the cam lobe to the valve (lifters, rocker arms, pushrods).

Vehicle Identification Number (VIN) - a number assigned to every vehicle as a unique identifier; includes vehicle specification information and a serial number.

voltage regulator - regulates the output of the alternator or DC generator to prevent overcharging of the battery.

--w--

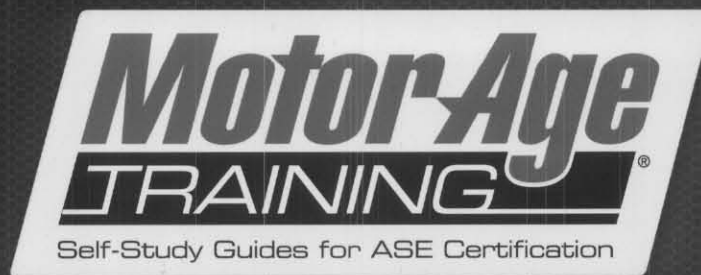
washers - discs that fit under screw heads or nuts to distribute force (see also lockwasher).

water pump - a belt-driven device that circulates coolant throughout the engine's cooling passages, radiator and heater core.

wheel cylinder - a component used on hydraulic brake systems. It is mounted to the backing plate and converts hydraulic pressure to the mechanical energy needed to apply the brake shoes to the drum.

working stock - that part of a store's inventory that covers normal sales (see also safety stock).

wrist pin - see piston pin.



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