Figure 66-1 The crude oil refining process showing most of the major steps and processes.

Figure 66-2 A gasoline testing kit, including an insulated container where water at 100°F is used to heat a container holding a small sample of gasoline. The reading on the pressure gauge is the Reid vapor pressure (RVP).
FREQUENTLY ASKED QUESTION
Why Do I Get Lower Gas Mileage in the Winter?
Several factors cause the engine to use more fuel in the winter than in the summer, including:

- Gasoline that is blended for use in cold climates is designed for ease of starting and contains fewer heavy molecules, which contribute to fuel economy. The heat content of winter gasoline is lower than summer-blended gasoline.
- In cold temperatures, all lubricants are stiff, causing more resistance. These lubricants include the engine oil, as well as the transmission and differential gear lubricants.
- Heat from the engine is radiated into the outside air more rapidly when the temperature is cold, resulting in longer run time until the engine has reached optimal operating temperature.
- Road conditions, such as ice and snow, can cause the brake or additional drag on the vehicle.

Figure 66-3
A typical distillation curve. Heavier molecules evaporate at higher temperatures and contain more heat energy for power, whereas the lighter molecules evaporate easier for starting.

Figure 66-4
An engine will not run if the air-fuel mixture is either too rich or too lean.
Figure 66-5: With a three-way catalytic converter, emission control is most efficient with an air-fuel ratio between 14.65 to 1 and 14.75 to 1.

Figure 66-6: Normal combustion is a smooth, controlled burning of the air-fuel mixture.

Figure 66-7: Detonation is a secondary ignition of the air-fuel mixture. It is also called spark knock or pinging.
FREQUENTLY ASKED QUESTION

What Grade of Gasoline Does the EPA Use When Testing Engines?

Due to the various grades and additives used in commercial fuel, the government (EPA) uses a liquid called indolene. Indolene has a research octane number of 96.5 and a motor method octane rating of 88, which results in an R + M ÷ 2 rating of 92.25.

TECH TIP: Horsepower and Fuel Flow

To produce 1 hp, the engine must be supplied with 0.50 lb of fuel per hour (lb/hr). Fuel injectors are rated in pounds per hour. For example, a V-8 engine equipped with 23 lb/hr fuel injectors could produce 110 hp per cylinder if the cylinder head or block is modified to produce more horsepower, this testing factor may be the limiting factor.

The following are flow rates and resulting horsepower for a V-8 engine:
- 30 lb/hr: 60 hp per cylinder or 480 hp
- 35 lb/hr: 70 hp per cylinder or 560 hp
- 40 lb/hr: 80 hp per cylinder or 640 hp

Of course, injector flow rate is only one of many variables that affect power output. Installing larger injectors without other major engine modifications could decrease engine output and drastically increase exhaust emissions.
The posted octane rating in most high-altitude areas shows regular at 85 instead of the usual 87.

FREQUENTLY ASKED QUESTION: Can Regular-Grade Gasoline Be Used If Premium is the Recommended Grade?  
Maybe. It is usually possible to use regular-grade or midgrade (plus) gasoline in most newer vehicles without danger of damage to the engine. Most vehicles built since the 1990s are equipped with at least one knock sensor. If a lower octane gasoline than specified is used, the engine ignition timing setting will usually cause the engine to spark knock, also called detonation or ping. The spark knock is detected by the knock sensor(s), which send a signal to the computer. The computer then retards the ignition timing until the spark knock stops.

FREQUENTLY ASKED QUESTION: What Is Meant by “Phase Separation”?
All alcohols absorb water, and the alcohol–water mixture can separate from the gasoline and sink to the bottom of the fuel tank. This process is called phase separation. To help avoid engine performance problems, try to keep at least a quarter tank of fuel at all times, especially during seasons when there is a wide temperature span between daytime highs and nighttime lows. These conditions can cause moisture to accumulate in the fuel tank as a result of condensation of the moisture in the air.
This refueling pump indicates that the gasoline is blended with 10% ethanol (ethyl alcohol) and can be used in any gasoline vehicle. E85 contains 85% ethanol and can be used only in vehicles specifically designed to use it.

A container with gasoline containing alcohol. Notice the separation line where the alcohol-water mixture separated from the gasoline and sank to the bottom.

In-line blending is the most accurate method for blending ethanol with gasoline because computers are used to calculate the exact ratio.
Sequential blending uses a computer to calculate the correct ratio as well as the prescribed order in which the products are loaded.

Splash blending occurs when the ethanol is added to a tanker with gasoline and is mixed as the truck travels to the retail outlet.

Checking gasoline for alcohol involves using a graduated cylinder and adding water to check if the alcohol absorbs the water.
**FREQUENTLY ASKED QUESTION**

Is Water Heavier Than Gasoline?
Yes. Water weighs about 8.3 pounds per gallon, whereas gasoline weighs about 6 pounds per gallon. The density as measured by specific gravity includes:
- Water = 1.000 (the baseline for specific gravity)
- Gasoline = 0.730 to 0.760
This means that any water that gets into the fuel tank will sink to the bottom.

**WARNING**

Do not smoke or run the test around sources of ignition!
FREQUENTLY ASKED QUESTION: How Does Alcohol Content in the Gasoline Affect Engine Operation?

In most cases, the use of gasoline containing 10% or less of ethanol (ethyl alcohol) has little or no effect on engine operation. However, because the addition of 10% ethanol raises the volatility of the fuel slightly, occasional rough idle or stalling may be noticed, especially during warm weather. The rough idle and stalling may also be noticeable after the engine is started, driven for a short time, then stopped. Engine heat can vaporize the alcohol-enhanced fuel causing bubbles to form in the fuel system. These bubbles in the fuel system can prevent the proper operation of the fuel injection system and result in a hesitation during acceleration, rough idle, or in severe cases repeated stalling. In these cases the proper operation of the fuel injection system and result in a hesitation during acceleration, rough idle, or in severe cases repeated stalling.

FREQUENTLY ASKED QUESTION: What Is Top-Tier Gasoline?

Top-tier gasoline is gasoline that has specific standards for quality, including enough detergent to keep all intake valves clean. Four automobile manufacturers, including BMW, General Motors, Honda, and Toyota, developed the standards. Top-tier gasoline exceeds the quality standards developed by the World Wide Fuel Charter (WWFC) that was established in 2002 by vehicle and engine manufacturers. The gasoline companies that agreed to make fuel that matches or exceeds the standards as a top-tier fuel include Shell, ChevronTexaco and ConocoPhillips. Ford has specified that BP fuel, sold in many parts of the country, is the recommended fuel to use in Ford vehicles.

TECH TIP: The Sniff Test

Problems can occur with stale gasoline from which the lighter parts of the gasoline have evaporated. Stale gasoline usually results in a no-start situation. If stale gasoline is suspected, sniff it. If it smells rancid, replace it with fresh gasoline.

NOTE: If storing a vehicle, boat, or lawnmower over the winter, put some gasoline stabilizer into the gasoline to reduce the evaporation and separation that can occur during storage. Gasoline stabilizer is frequently available at lawnmower repair shops or marinas.
FREQUENTLY ASKED QUESTION: Why Should I Keep the Fuel Gauge Above One-Quarter Tank?

The fuel pickup inside the fuel tank can help keep water from being drawn into the fuel system unless water is all that is left at the bottom of the tank. Over time, moisture in the air inside the fuel tank can condense, causing liquid water to drop to the bottom of the tank. However, when water combines with alcohol, a separation layer occurs between the gasoline at the top of the tank and the alcohol–water combination at the bottom. When the fuel level is low, the fuel pump will draw from this concentrated level of alcohol and water. Because alcohol and water don’t mix as well as pure gasoline, severe driveability problems can occur such as stalling, rough idle, hard starting, and missing.

FREQUENTLY ASKED QUESTION: Do Not Overfill the Fuel Tank

Gasoline fuel tanks have an expansion volume area at the top. The volume of this expansion area is about 10% to 15% of the volume of the tank. This area is normally not filled with gasoline, but rather is designed to provide a place for the gasoline to expand into, if the vehicle is parked in the hot sun and the gasoline expands. This prevents raw gasoline from escaping from the fuel system. A small restriction is usually present to control the amount of air and vapors that can escape from the tank.

The volume area at the top with gasoline is the same for all fuels, even when the tank is partially filled. The fuel pump can still draw from the center of the tank. Some people believe they can fill the tank completely by pumping gasoline into the fuel tank, but pumping gasoline in an attempt to fill the tank completely can cause a rich air-fuel mixture. Not only can this liquid fuel harm vapor recovery parts, but overfilling the gas tank could also cause the vehicle to fail an exhaust emission test, particularly during an enhanced test when the tank could be purged while on the rollers.

WARNING

Many gasoline service stations have signs posted warning customers to place plastic fuel containers on the ground while filling, if placed in a truck or pickup truck bed, equipped with a plastic liner, static electricity could build up during fueling and discharge from the container to the metal nozzle and cause a spark and possible explosion. Some service stations have warning signs not to use cell phones while fueling to help avoid the possibility of an accidental spark creating a fire hazard.
FREQUENTLY ASKED QUESTION

What Are the Pump Nozzle Sizes?

Unleaded gasoline nozzles are smaller than those used for diesel fuel to help prevent fueling errors. However, it is still possible to fuel a diesel vehicle with gasoline. See Chart 66-1 for the sizes and colors used for fuel pump nozzles.

CHART 66-1

FUEL PUMP NOZZLE SIZE

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Nozzle Diameter</th>
<th>Pump Handle Color (Varies—no established standard)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>13/16 in. (21 mm)</td>
<td>Black, red, white, green, or blue</td>
</tr>
<tr>
<td>E10</td>
<td>13/16 in. (21 mm)</td>
<td>Black, red, white, green, or blue</td>
</tr>
<tr>
<td>E85</td>
<td>13/16 in. (21 mm)</td>
<td>Yellow or black</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>15/16 in. (24 mm)</td>
<td>Yellow, green, or black</td>
</tr>
<tr>
<td>Biodiesel</td>
<td>15/16 in. (24 mm)</td>
<td>Green</td>
</tr>
<tr>
<td>Truckstop</td>
<td>1.1/16 or 1 1/2 in. (32 or 38 mm)</td>
<td>Varies</td>
</tr>
<tr>
<td>diesel</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

TESTING FOR ALCOHOL CONTENT IN GASOLINE

A fuel composition tester (SPX Kent-Moore 146175) is the recommended tool, by General Motors, to test the alcohol content of gasoline.
Testing for Alcohol Content in Gasoline

This battery-powered tester uses light-emitting diodes (LEDs), meter lead terminals, and two small openings for the fuel sample.

The first step is to verify the proper operation of the tester by measuring the air frequency by selecting AC hertz on the meter. The air frequency should be between 35 and 40 Hz.

After verifying that the tester is capable of correctly reading the air frequency, gasoline is poured into the testing cell of the tool.
Record the AC frequency as shown on the meter and subtract 50 from the reading (e.g., 60.50 – 50.00 = 10.5). This number (10.5) is the percentage of alcohol in the gasoline sample.

Adding additional amounts of ethyl alcohol (ethanol) increases the frequency reading.