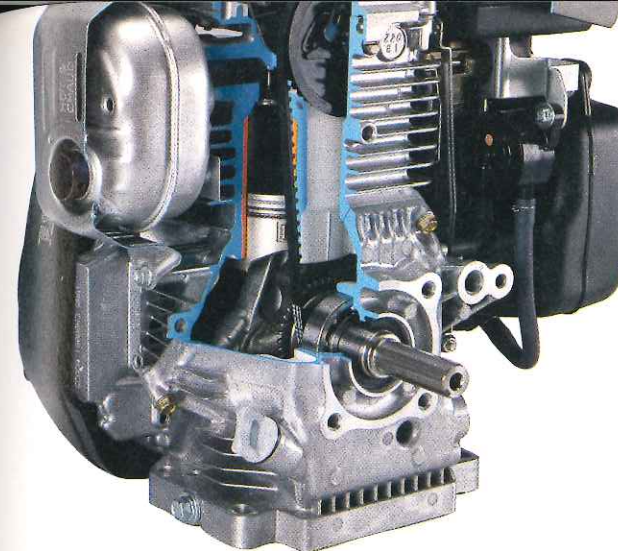




Fuel and Emission Control Systems

After studying this chapter, you will be able to:

- ▼ Name various types of fuel that can be used in a small engine and list practical applications for each.
- ▼ Explain the importance of proper fuel-oil mixture in a two-cycle engine.
- ▼ Describe the purpose of fuel filters.
- ▼ Explain fuel pump operation.
- ▼ Describe the operation of a pressurized fuel system.
- ▼ Explain the importance of emission control.

Engine Fuels

Small gas engines can be designed to operate efficiently on gasoline, liquefied petroleum gas, natural gas, kerosene, or diesel fuel. See **Figure 7-1**. Gasoline is the most popular small engine fuel. Refer to *Fuel Recommendations* in the *Appendix* section.



In addition to its power potential, gasoline is readily available and easily transported for refueling. See **Figure 7-2**.

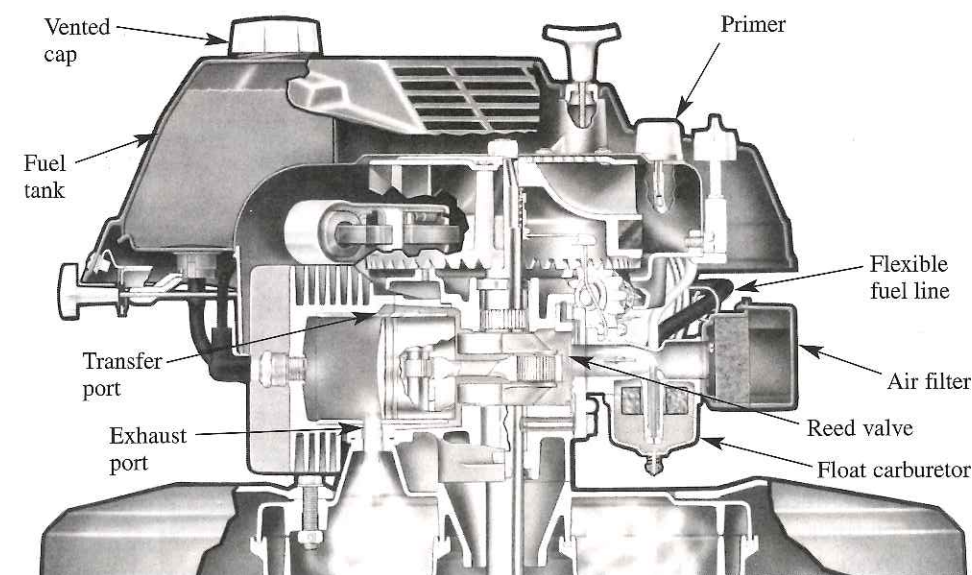


Figure 7-1. Callouts identify components of a typical fuel system on a two-cycle engine used in a power mower application.



Figure 7-2. Refueling a four-cycle engine requires use of an approved fuel can and a fresh fill of regular gasoline.

Gasoline

Most small engine manufacturers specify the use of regular grade, unleaded gasoline with an octane rating around 90. Occasionally, premium fuels are recommended for use in hot climates. This practice may prevent detonation or *dieseling* (after-run). However, a heavier buildup of solid materials in the combustion chamber can be expected from premium fuels because they contain more additives than regular grade fuels.



Gasoline should be clean, free from moisture, and reasonably *fresh*. After prolonged storage, especially in small quantities, gasoline tends to become *stale*. This is caused by oxidation that forms a sticky, gum-like material. This gum can clog small passageways in the carburetor and cause poor engine performance or hard starting.

Fuel stabilizers

There is a variety of fuel stabilizers available for all two- and four-stroke gasoline powered engines. Particularly in small engines, a fuel stabilizer will keep fresh fuel fresh and promote quick, easy starts after the engine has been stored for an extended time. Fuel stabilizers prevent fuel

deterioration and protects engines from gum, varnish, rust, and corrosion. It is not necessary to drain fuel before adding fuel stabilizer. Most fuel stabilizer containers have an automatic measuring design to add stabilizer to the fuel tank or storage container. See **Figure 7-4**. The amount of stabilizer to use is relative to the quantity of fuel in the tank or container. Follow the recommendations on the label of the container. Fuel stabilizers contain petroleum distillate and should be used in accordance with the safety precautions on the label.

Liquefied petroleum gas and natural gas

Liquefied petroleum gas (LPG) may be propane, butane, or a mixture of both. Properly designed fuel systems allow the use of LPG with no appreciable loss of horsepower, when compared to a similar engine burning gasoline. LPG burns cleanly and leaves few combustion chamber deposits. Because they emit fewer noxious fumes, these engines are often used in warehouses, factories, etc. LPG also has a high anti-knock rating.

Natural gas generally causes a horsepower loss of around 20% when compared with gasoline. Both LPG and natural gas require a different fuel

Marked measuring device



Figure 7-3. A fuel stabilizer is used to keep fuel fresh and promote quick, easy starts after the engine has been stored for an extended time.

system setup than the conventional type used for supplying gasoline. **Figure 7-4** shows the components of one type of LPG system.

Combustion of LPG

LPG burns slower than gasoline because it has higher ignition temperatures. For this reason, the timing is often advanced on LPG engines.

Due to the higher ignition temperatures, greater voltage at the spark plugs may be needed for LPG combustion. *Colder* plugs or smaller spark plug gaps may solve this problem. Check the engine manual for recommendations.

Less heat is required at the intake manifold to vaporize LPG than gasoline. LPG vaporizes at much lower temperatures than gasoline. It vaporizes at room temperature. This results in less wasted heat and more heat being converted to engine power.

Advantages of LPG

- Cheaper, especially when close to the source (refinery).
- Less oil consumption due to engine wear.
- Reduced maintenance costs—longer engine life between overhauls.
- Smoother power from the slow, even burning of LPG.
- Fewer noxious or poisonous exhaust gases, such as deadly carbon monoxide gas.

Disadvantages of LPG

- Initial equipment costs are high. Bulk fuel storage and carburetion equipment are costly.
- Fewer accessible fuel points (gas stations).
- Harder to start in cold weather—0°F (−18°C) or below.

Kerosene and diesel fuels

Some non-diesel type small gas engines can be converted to operate successfully on *kerosene* or fuel oil through the installation of a low compression cylinder head and a special carburetor. These engines are started and operated on gasoline until fully warm, then switched over to the kerosene or fuel oil. These fuel installations are generally limited to heavy-duty, industrial engines.

A true diesel engine uses *diesel fuel* injected into the cylinder where it is ignited by the heat of compression. It is not unusual to have compression ratios as high as 20 to 1. Currently, however, diesel application in the small engine field is somewhat limited. It is only practical on applications where continuous use for long periods of time are common.

Two-cycle fuel mixtures

Most two-cycle engines receive lubrication only from the oil mixed with the gasoline. Because of this, it is important that the correct quantity and

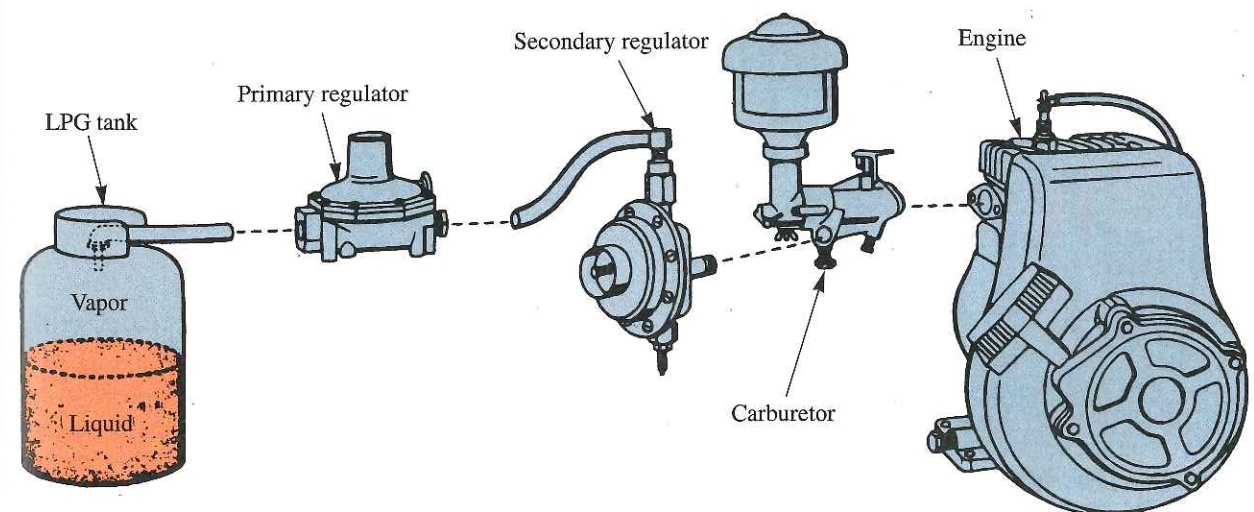


Figure 7-4. Typical LPG fuel system using vapor withdrawal. (Clinton Engine Corp.)

proper quality of oil is thoroughly mixed with a specific amount of gasoline.



Always follow the manufacturer's recommended specifications as to the type and quantity of oil to use.

Too little oil can cause the engine to overheat. Overheating, in turn, causes expansion of parts and possible scoring of machined surfaces. Eventually, the pistons may seize (bind, then stick) in the cylinders. Excessive oil, on the other hand, will cause incomplete combustion and rapid buildup of carbon, fouling the spark plugs and adding weight to the pistons.

Tanks, lines, and fittings

Small engine fuel tanks are made of metal or plastic. Some are mounted away from the engine. See **Figure 7-5**. Others are contoured to fit snugly around the engine. See **Figure 7-6**.

The tank filler cap is vented. If the vent becomes clogged, the engine will create enough vacuum in the tank to cause fuel starvation. Most filler caps have baffles and filters. See **Figure 7-7**.

The purpose of a fuel tank filler cap with a screw vent is to prevent fuel evaporation when the vent is closed. The vent should be opened before starting the engine. A variety of cap styles are shown in **Figure 7-8**.



Figure 7-5. Portable engine-driven generator with the fuel tank mounted on top side opposite carburetor. (Generac Corp.)



Figure 7-6. On this lawn mower the plastic fuel tank is contoured to fit snugly around engine.

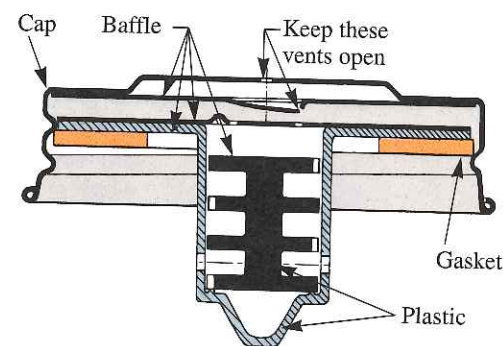


Figure 7-7. Vented fuel filler caps are baffled to prevent dirt and dust from entering fuel tank. (Clinton Engine Corp.)

Fuel tanks used in all terrain vehicles (ATVs) and snowmobiles often have the **fuel pick-up line** inserted from the top of the tank. The pick-up line usually is very flexible and weighted at the bottom, so the line will always be where the fuel is deepest in the tank when the vehicle is at a steep angle.

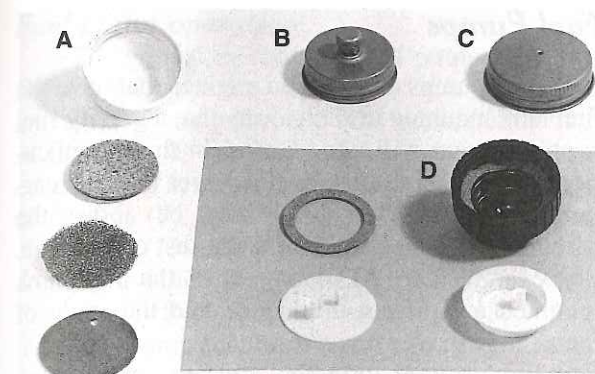


Figure 7-8. Fuel filler caps: A—Plastic cap with plastic fabric as a filter and a perforated fiber disc. B—Cap with a threaded screw vent, which will seal tank. C—Standard cap with a single vent hole. D—Three-piece plastic cap showing maze-type baffle with fiber gaskets.

Fuel filters

Some small engines have a fuel line fitting in the bottom of the tank. A filter screen is placed in the tank fitting or at the end of the pick-up line. See **Figure 7-9**. A top mounted pick-up line with the filter element at the bottom end is shown in **Figure 7-10**.

Other engines have a bottom mounted fuel fitting with a shutoff valve threaded into the tank. See **Figure 7-11**.

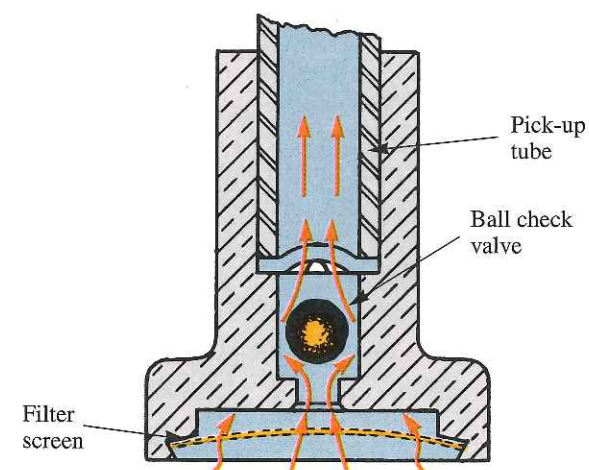


Figure 7-9. A filter and ball check valve attached to end of a fuel pick-up tube. Ball check valve prevents fuel from draining back into tank when the engine is running. (Clinton Engine Corp.)

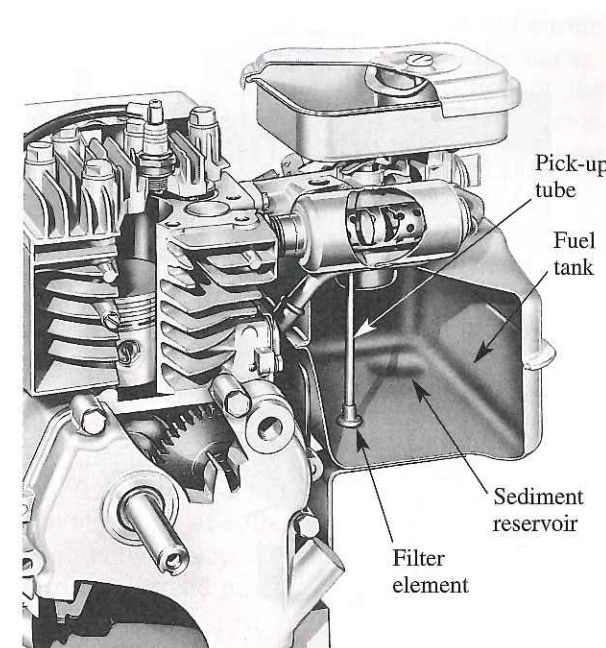


Figure 7-10. This fuel tank cutaway shows a pick-up tube in the tank with a ball check valve and a filter element attached. (Briggs and Stratton Corp.)

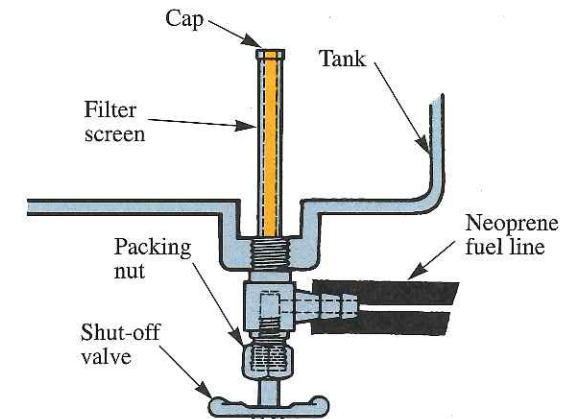


Figure 7-11. A shutoff valve in the tank is necessary to stop the loss of fuel whenever a part of the fuel system is undergoing work. The filter screen is a permanent part of the valve. Care during installation is necessary. (Lawn-Boy Power Equipment, Gale Products)

Older small engines have a more elaborate filter incorporated in a glass sediment bowl. See **Figure 7-12**. The gasket, screen, and bowl can be removed for inspection and cleaning. A similar filter is shown in **Figure 7-13**. It is mounted directly on the fuel tank and has a shut-off valve.

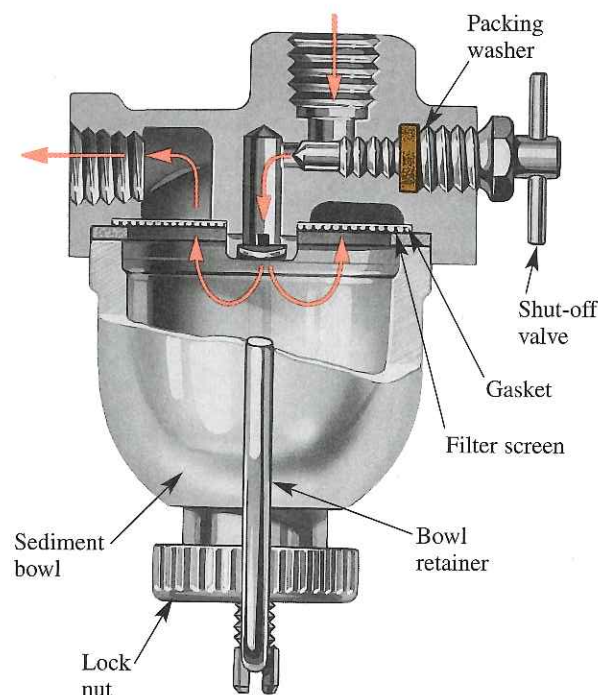


Figure 7-12. Some small engines have remote fuel strainers located somewhere along the fuel line. The glass bowl permits visual inspection without dismantling. (Wisconsin Motors Corp.)

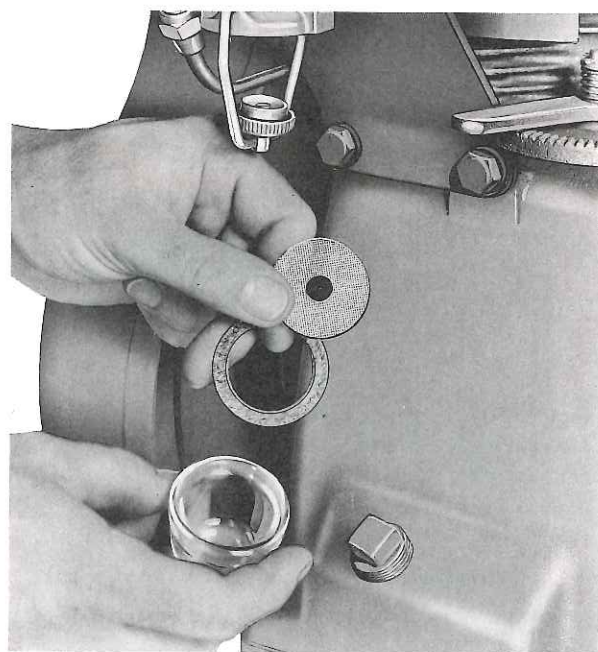


Figure 7-13. When moisture or dirt is found in the sediment bowl, the fuel strainer can easily and quickly be taken apart for cleaning. The fuel shut-off valve is closed before removing the bowl.

Fuel Pumps

Fuel pumps are used on engines that have the fuel tank mounted in such a way that a gravity fuel supply system will not operate. In these applications, the tank and fuel level is lower than the carburetor, or the fuel level may be above the carburetor at times and below the rest of the time. For example, an ATV may have the fuel tank mounted away from the engine and the angle of the vehicle may change constantly.

Fuel pumps provide constant, pressurized fuel flow to the carburetor under changing conditions. They help ensure that the engine can always provide quick acceleration and constant full power.

Mechanical fuel pumps

The mechanical fuel pump used on small engines is basically the same as the type used on automobile engines. It may include a filter as part of the pump design. **Figure 7-14** is a cutaway view of a combination fuel pump and filter system. Trace the arrows to follow the flow of fuel.

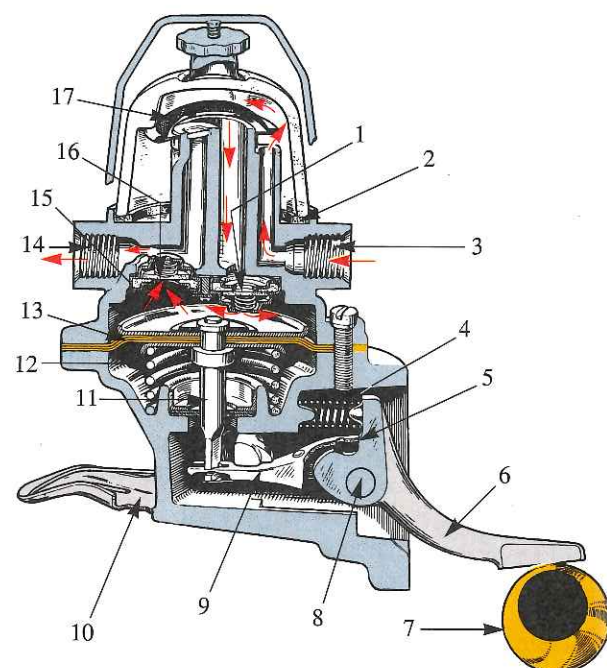


Figure 7-14. A cutaway of a mechanical fuel pump with a combined fuel strainer on top. Pumps are activated by the camshaft (7) as shown. The diaphragm (13) pulsates and forces fuel through the check valves (1) and (16).

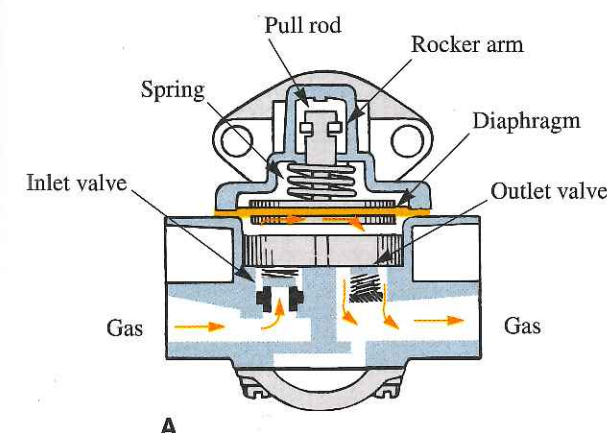
Fuel pump operation

The typical mechanical fuel pump shown in **Figure 7-14** operates by means of a diaphragm and atmospheric pressure on the surface of the fuel in the tank. As the engine camshaft revolves, an eccentric (7) actuates the fuel pump rocker arm (6) pivoted at (8). This pulls the pull rod (11) and diaphragm (13) down against spring pressure (12), creating a depression in the pump chamber (15). Fuel drawn from the tank enters the glass bowl from the pump intake (3). After passing through the filter screen (17) and the inlet valve (1), the fuel enters the pump chamber (15).

On the return stroke, pressure of the spring (12) pushes the diaphragm (13) upward, forcing fuel from the chamber (15) through the outlet valve (16) and outlet (14) to the carburetor. When the carburetor bowl is full, the carburetor float will seat the needle valve, preventing any flow from the pump chamber (15). This will hold the diaphragm (13) down against the spring pressure (12). It will remain in this position until the carburetor requires additional fuel and the needle valve opens. The rocker arm (6) operates the connecting link (9) by making contact at (5). This construction allows idling movement of the rocker arm without moving the fuel pump diaphragm. The spring (4) keeps the rocker arm in constant contact with the eccentric (7) to eliminate noise.

Fuel pump hand primer

The **hand primer** shown as (10) in **Figure 7-14** is used when the carburetor float bowl or pump bowl has become empty. By pulling the hand



primer upward, the float bowl will fill and ensure easy starting without prolonged use of the starter.

Because of the special construction of the pump, it is impossible to overprime the carburetor. After several strokes of the hand primer, its handle will become free acting. This indicates that the float bowl is full.

Fuel pump without a filter system

The fuel pump in **Figure 7-15A** is a mechanical pump without a filter chamber. It is mounted on the crankcase, **Figure 7-15B**. A separate filter may be installed somewhere along the fuel line. In some applications, the system may rely solely on the pick-up line filter, a filter in the carburetor, or a combination of both. **Figure 7-16** shows a combination fuel pump and filter system. Note shut-off needle valve and primer lever.

Impulse diaphragm fuel pumps

One type of diaphragm fuel pump sometimes used on small gas engines is activated by the pulsing vacuum in the intake manifold or crankcase. Four-cycle engines use the intake manifold vacuum; two-cycle engines use crankcase vacuum.

A typical impulse diaphragm pump is illustrated in **Figure 7-17**. When vacuum draws the diaphragm upward against spring tension, the inlet check valve opens to allow fuel to flow in. When vacuum is relieved, the spring pushes the diaphragm downward to force fuel through the outlet check valve. This process is repeated as long as the engine is running.

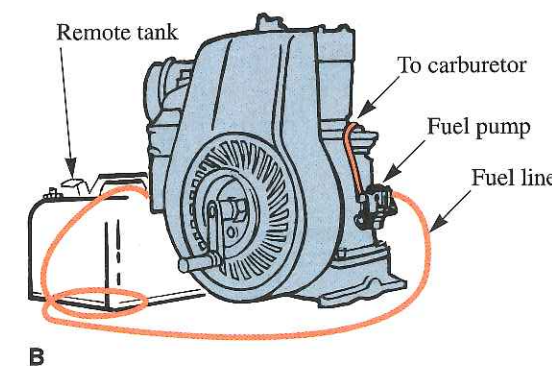


Figure 7-15. A—A diaphragm fuel pump without a combined filter. B—The pump is cam operated and can pump fuel from portable fuel tanks if necessary. (Clinton Engine Corp.)

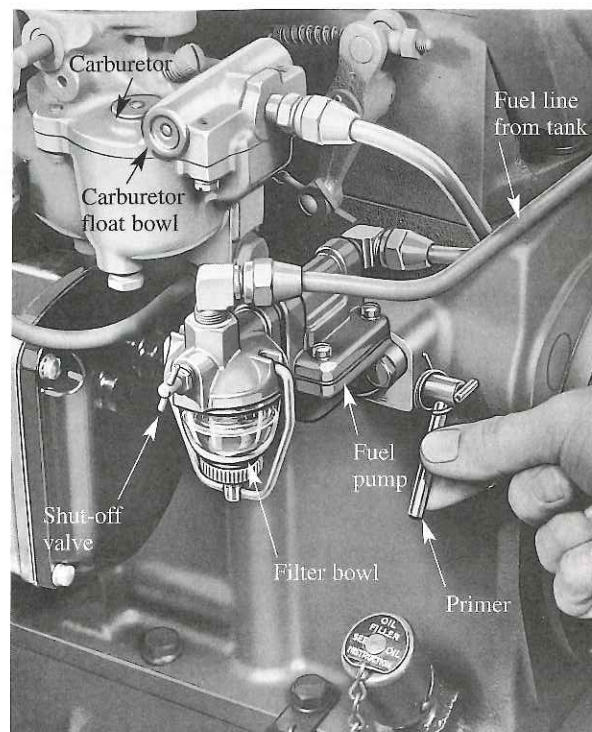


Figure 7-16. A combination fuel pump and filter mounted in tandem. The fuel pump has a manual primer used to initially get fuel to the carburetor. (Wisconsin Motors Corp.)

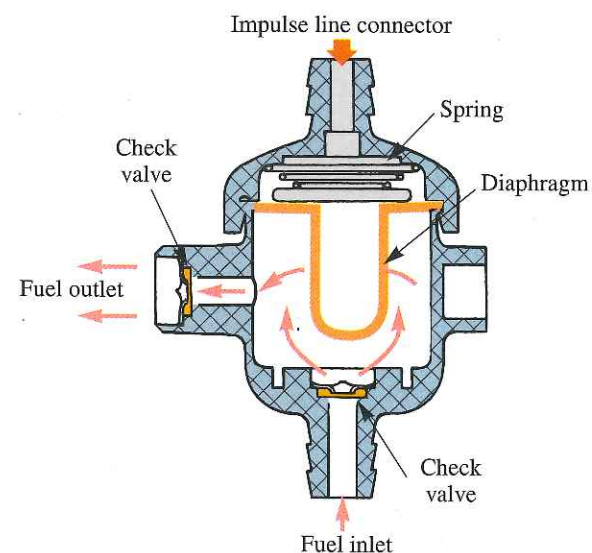
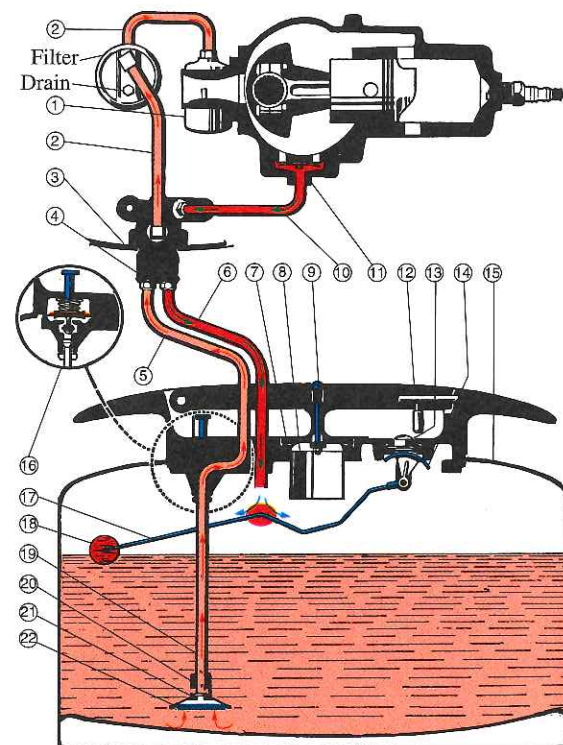


Figure 7-17. This fuel pump is operated by vacuum pulses transferred from the engine crankcase. It can be mounted in any convenient location on the engine. (Clinton Engine Corp.)

It is common practice today to design the impulse diaphragm fuel pump directly into the carburetor. This design principle will be explained in the next chapter.

Pressurized fuel system

A **pressurized fuel system** is used when the fuel tank is located a considerable distance below the carburetor. See **Figure 7-18**. Outboard engines, for example, often operate from portable tanks resting in the bottom of the boat. The



- | | |
|---------------------------------------|----------------------------------|
| 1-Carburetor. | 11-Pressurized valve, crankcase. |
| 2-Fuel line, filter to carburetor. | 12-Release latch. |
| 3-Bottom cowl. | 13-Magnifying lens. |
| 4-Twist connector. | 14-Graduated sector. |
| 5-Fuel line, tank to twist connector. | 15-Remote fuel tank. |
| 6-Air line, tank to twist connector. | 16-Priming pump. |
| 7-Seal. | 17-Float arm. |
| 8-Extension tube, filler opening. | 18-Float. |
| 9-Pressure relief valve. | 19-Fuel pick-up tube. |
| 10-Air line, crankcase to connector. | 20-Disc filter. |
| | 21-Check valve. |
| | 22-Strainer. |

Figure 7-18. A pressurized fuel system uses crankcase pressure transferred to the fuel tank. Pressure on the surface of the fuel forces fuel into the engine. (Evinrude Motors)

pressurized fuel system shown in **Figure 7-18** operates as follows:

1. The carburetor (1) is connected to the fuel tank (15) through the fuel filter by fuel lines (2 and 5).
2. Fuel flow from the tank to the carburetor is induced by pressure transmitted from the crankcase to the air space above the fuel line level via the air line (10), which runs from pressurized valve (11) to the twist connector (4) and into the top of the fuel tank (6).
3. For starting, initial flow to the carburetor is induced by the hand-operated priming pump (16).
4. A disc filter (20) is incorporated in the bottom of the fuel pick-up tube (19).
5. The fuel level is indicated by a graduated sector (14), actuated by a float (18) attached to arm (17).
6. The pressure relief valve (9) in the center of the carrying handle permits relieving pressure when necessary.
7. The check valve in the twist connector (4) permits disconnecting the air-fuel line without loss of tank pressure.
8. The tank pressure forces fuel up through the pick-up line (19), through the filter, and into the carburetor (1).

9. The check valve (21) is essential to the operation of the priming pump (16). It prevents fuel from draining back into the tank.

Vapor return fuel systems

If the temperature of the air around or inside a carburetor becomes high enough to vaporize the gasoline, pockets of vapor will stop all flow of fuel. When this occurs, the engine will become **vapor locked**. It will not run until the temperature drops low enough for the vapor to condense (return to a liquid).

One of the best ways to prevent vapor lock is to use a carburetor with a vapor return line. In these systems, any vapor that forms is directed back into the fuel tank where the built-up pressure is vented to the atmosphere.

A diagram of a typical vapor return fuel system is shown in **Figure 7-19**. The carburetor in this system has a built-in diaphragm fuel pump. The impulse tube operates the pump.

Small Engine Emissions

Emissions from lawnmowers, snow blowers, chain saws, leaf vacuums, and similar outdoor power equipment are significant sources of pollu-

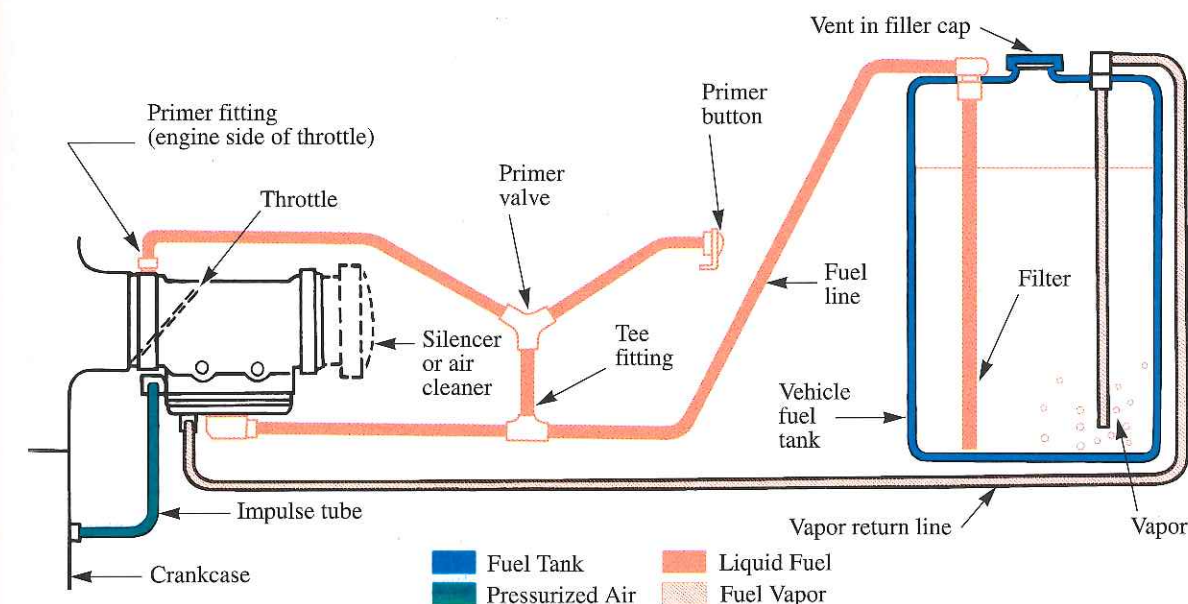


Figure 7-19. A vapor return fuel system is one of the best methods for preventing a vapor lock. Vapors formed by heat are directed back to the fuel tank where they are cooled and condensed to liquid form. (Kohler Co.)

tion. In the United States alone, walk-behind lawnmowers, chain saws, string trimmers, garden tractors, Rototillers®, and leaf blowers generate millions of tons of air pollution (the combined hydrocarbon, oxides of nitrogen, and carbon monoxide contribution) each year. Mowing a lawn for a half-hour with a typical mower can produce as much smog as driving a car 172 miles.

Engine exhaust emissions have come under considerable examination. Today's small engines emit oxides of nitrogen (NO_x) and high levels of carbon monoxide (CO). CO is an odorless, colorless, and poisonous gas. These engines also emit hydrocarbons (HC), which contribute to the formation of ground-level ozone. Ground-level ozone, a component of smog, is a noxious irritant that impairs lung function and inhibits plant growth.

Although exhaust by-products are the major source of harmful small engine emissions, evaporative emissions also contribute to environmental and health problems. Lawn-and-garden equipment refueling losses account for 72% of the evaporative emissions from nonroad engines. Americans spill over 17,000,000 gallons of gasoline every summer while refueling their lawn-and-garden equipment. This is enough gasoline to fill approximately 24 Olympic-size swimming pools. All this gasoline evaporates into the air, where it contributes to the formation of ground-level ozone, irritating the eyes, damaging the lungs, and aggravating respiratory problems. **Figure 7-20** shows a new type of pouring device designed to eliminate gasoline spillage. The Sure Pour Nozzle® stops pouring automatically when the fuel tank is full. After use, the nozzle seals the container to prevent evaporation of fuel into the atmosphere.

Emission control regulations

In 1970, the U.S. government made a significant effort to combat the steadily increasing level of air pollutants. At this time, the **Federal Clean Air Act** was passed. This act was aimed at ridding the atmosphere of harmful road vehicle emissions.

Since that time, there has been an increased awareness of the harmful emissions generated by small gas engines. The 1990 amendment to the Clean Air Act initiated legal authority to regulate small engine emissions.

Small gas engine manufacturers have dedicated great amounts of time, money, and engineering expertise to make their engines perform more efficiently to meet demanding requirements. The **California Air Resources Board (CARB)** established a public hearing in 1990 to consider regulations regarding the California exhaust emission standards and test procedures for utility and lawn-and-garden equipment engines. This resulted in very detailed and extensive regulations for the testing and monitoring of manufactured engines.

The new regulations first took effect in California in 1995. The restrictions were met by engines manufactured during the 1995 model year. Most engine manufacturers claim to have accomplished this through combinations of better oil control, design of combustion chambers, carburetion, ignition systems, overhead valves, and valve timing. So far, catalytic converters similar to those used on road vehicles have not been needed. When stricter standards are implemented, widespread use of catalytic converters, fuel injection, and overhead valve arrangements may be necessary.

Since the mid-1990s, more legislation and amendments have been passed that establish exhaust emission standards and test procedures for engines used in lawn-and-garden equipment, as well as those used in other utility equipment.

The **Environmental Protection Agency (EPA)** has also become involved in reducing air pollution generated by small gasoline engines. In April, 1994, the EPA proposed the Federal Limits. In July of 1995, the EPA published the Phase 1 Standards for Small Spark-Ignition Engines to regulate air emissions from small engines used in residential and commercial equipment. Phase 2 Standards for Small Spark-Ignition Engines, which proposed even stricter emissions guidelines, were adopted in April of 2000 and phased in between the 2002 and 2007 model years. Phase 3 guidelines were proposed in May of 2007, and will be phased in between the 2009 and 2012 model years.

In addition to pursuing regulatory emission controls, the EPA works with manufacturers, dealers and retailers, environmental and health groups, and consumers to promote pollution reduction. With the expected growth in the use of small engine-powered equipment, air pollution from these sources would continue to grow. Implementation of the EPA's

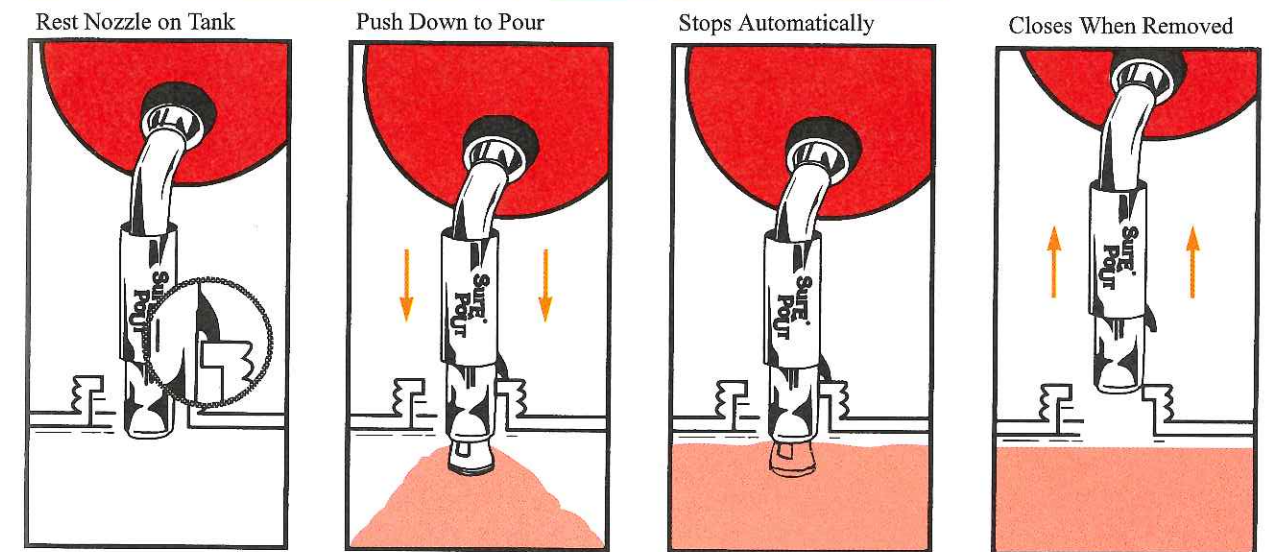


Figure 7-20. New products, such as this pouring device, are produced to help prevent environmental and health hazards. (VEMCO, Inc.)

emission standards is expected to slow, or in some cases reverse, the increase in air pollution over the next several decades.

The goal of emission control standards is to create low-emissions engines that are both user friendly and environmentally friendly. Low-emission engines must be tuned precisely, which results in a finer margin of error when making repairs. Repairs or adjustments that put the engine out of compliance with the emissions regulations are prohibited. Service technicians must be especially precise in their repair and adjustment of ignition and fuel system components.

Phase 1 Standards for Small Spark-Ignition Engines

In 1995, the EPA, with input from engine and equipment manufacturers, developed the **Phase 1 Standards for Small Spark-Ignition Engines**. The regulations set down in this document were a first step toward reducing hydrocarbon, carbon monoxide, and nitrous oxides emissions from nonroad spark-ignition engines with a gross power output at or below 19 kW (25 hp). Such engines are typically used in power lawn-and-garden equipment, small farm

and construction equipment, commercial turf equipment, and utility equipment, **Figure 7-21**.

The emission standards set forth in the Phase 1 regulations were chosen because they were demonstrated to be achievable and cost effective using the technology available at the time. The goal of the Phase 1 limits was to reduce emissions of hydrocarbon and oxides of nitrogen by roughly 32%. Manufacturers were given the flexibility to use any method to achieve the mandated emissions levels, as long as it was safe.

The limits set on emissions were based on five displacement classes—two for non-handheld equipment and three for handheld equipment. Non-handheld limits applied primarily to four-stroke engines, and handheld limits applied primarily to two-stroke engines. Because the manufacturers of 2-stroke lawnmower engines demonstrated that it was prohibitively expensive and complicated to make their engines meet the same emissions requirements as four-stroke engines, they were granted special dispensation

Engines Subject to Proposed Phase 1	
Non-handheld	Handheld
lawnmowers	trimmers
tillers	edgers
chippers	brush cutters
generator sets	leaf blowers
pumps	leaf vacuums
air compressors	chain saws
aerial lifts	shredders
lawn and garden tractors	augers
wood splitters	
commercial turf equipment	
pressure washers	
golf carts	
forklifts	
sweepers	

Figure 7-21. Several types of utility, and lawn and garden equipment are regulated under the Phase 1: Small Spark-Ignition Engine Rule.

that allowed them to be regulated by the handheld equipment limits rather than the tighter, non-handheld equipment limits.

Phase 2 Standards for Small Spark-Ignition Engines

In April of 2000, the EPA established a new set of limits on emissions from small spark-ignition engines. These new limits were referred to as the *Phase 2 Standards for Small Spark-Ignition Engines*. The goal of the Phase 2 emission standards was to lower emissions of hydrocarbons and oxides of nitrogen by an additional 70%. The Phase 2 standards were phased in between the 2002 and 2007 model years.

In order to comply with the stricter emissions limits, many manufacturers of larger non-handheld equipment engines switched to overhead valve engine designs. Most manufacturers of smaller engines were able to adapt their existing designs to meet the requirements.

The Phase 2 standards also added two new non-handheld engine classifications, I-A for engines with displacement under 66cc and I-B for engines with displacements between 66cc and 100cc. The Phase 2 standards also instituted a program of certification, assembly line testing, and in-use testing to ensure that engines meet emissions requirements throughout their active service life.

Phase 3 Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels

In April of 2007, the EPA proposed a new set of standards to regulate emissions from small engines. These new regulations were entitled *Phase 3 Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels*. When enacted, the Phase 3 standards are expected to further reduce emissions of hydrocarbons, oxides of nitrogen, and carbon monoxide from small (25 hp and under) spark-ignition engines, marine outboard engines, and personal watercraft engines.

In addition to further tightening the limits for exhaust emissions, the Phase 3 regulations also

limit evaporative emissions. As the name implies, evaporative emissions result from the evaporation of fuel caused by fuel spills during refueling, fuel vapors permeating the fuel lines and tank, and venting of the fuel system. The new regulations will be phased in between the model years 2009 and 2012 and will likely require manufacturers of some engines to employ such technologies as catalytic treatment of exhaust, low-permeation tanks and hoses, and fuel injection.

Impact of EPA Regulations on the Service Technician

As a small engine service technician, you should keep up to date on all applicable EPA regulations, which you can find in their entirety at www.epa.gov/otaq/. You have a legal responsibility when working on a small gas engine to make sure that your repairs or adjustments do not cause the engine's emissions to exceed the limits set forth by the EPA. For this reason, it is important to know which set of regulations apply to the engine you are working on.

Role of the consumer

Both residential and commercial consumers must take an active role in preventing pollution from lawn-and-garden equipment. The type of equipment chosen and the way the equipment is used can have an impact on preventing pollution.

New technology is beginning to appear in the marketplace in the form of changes to traditional gasoline-powered engines, as well as alternative power sources, such as electricity and solar energy.

As the new technology emerges, it will be increasingly important for the consumer to follow manufacturer's suggested maintenance procedures. This will result in reduced pollution, longer lasting and better performing engines, and a healthier environment.

In an attempt to involve the consumer, the EPA is beginning a pilot pollution prevention communication strategy. The focus of this program is to educate residential and commercial small engine users about spillage during refueling. This is a problem only the consumer can fix.

Summary

Small gas engines can be designed to operate on gasoline, LPG, natural gas, kerosene, or diesel fuel. Most manufacturers specify the use of unleaded gasoline with an octane rating around 90. Gas should be clean, free from moisture, and reasonably fresh. Two-cycle engines receive lubrication from oil that is mixed with fuel. Always follow the manufacturer's specifications for the type and quantity of oil to use. Small engine fuel tanks are made of metal or plastic. Various types of fuel filters are used in small engines.

Fuel pumps are used on engines that do not have a gravity fed fuel supply system. Fuel pumps provide constant, pressurized fuel flow to the carburetor under changing conditions. Mechanical fuel pumps are usually driven by the camshaft. Diaphragm fuel pumps are activated by the pulsing vacuum in the intake manifold or the crankcase. Pressurized fuel systems are used when fuel tanks are located a considerable distance below the carburetor.

Emissions from outdoor power equipment are significant sources of pollution. Today's small engines emit oxides of nitrogen (NO_x), carbon monoxide (CO), and hydrocarbons (HC). Although exhaust by-products are the major source of harmful small engine emissions, evaporative emissions also contribute to environmental and health problems.

In 1970, the Federal Clean Air Act was passed. This act was aimed at ridding the atmosphere of harmful road vehicle emissions. The 1990 amendment to the Clean Air Act initiated legal authority to regulate small engine emissions.

The California Air Resources Board (CARB) established a public hearing in 1990 to consider regulations regarding the California exhaust emission standards and test procedures for utility and lawn-and-garden equipment engines. This resulted in very detailed and extensive regulations for the testing and monitoring of manufactured engines. The new regulations took effect in 1995.

Beginning in the mid-1990s, federal regulations were passed that established exhaust emission standards and test procedures for engines

used in lawn-and-garden equipment, as well as those used in other utility equipment.

The EPA emissions standards for small spark-ignition engines began with the Phase 1 standards in 1995. The Phase 2 standards tightened the limits on emissions and were phased in during the 2002 and 2007 model years. Many manufacturers switched to overhead valve designs to comply with the Phase 2 regulations. The EPA's Phase 3 standards will be phased in between model years 2009 and 2012. Many manufacturers are expected to employ technologies such as catalysts, low-permeation fuel lines and tanks, and fuel injection to comply with the Phase 3 standards. It is the service technician's responsibility to know which set of regulations apply to the engine he or she is working on.



Know These Terms

LPG	Phase 1 Standards for Small Spark-Ignition Engines
kerosene	Phase 2 Standards for Small Spark-Ignition Engines
diesel fuel	Phase 3 Emission Standards for New Nonroad Spark-Ignition Engines, Equipment, and Vessels
fuel pick-up line	
fuel pump	
hand primer	
pressurized fuel system	
vapor lock	
Federal Clean Air Act	
California Air Resources Board (CARB)	
Environmental Protection Agency (EPA)	



Chapter 7 Review Questions

Answer the following questions on a separate sheet of paper.

- In addition to the power available from gasoline, give three other reasons for its wide acceptance for engine use.
- Most manufacturers specify regular grade, unleaded gasoline for small engines. True or False?
- Premium fuels are sometimes recommended for use in hot climates. True or False?
- A greater buildup of solid materials in the combustion chamber could be expected from using regular grade fuel. Yes or No?
- Premium fuels contain more additives than regular grade fuels. True or False?
- LPG is either _____ or _____ or a mixture of both.
- Natural gas used as a small engine fuel is generally accompanied by a horsepower loss of _____ percent.
- If excessive oil is mixed with the fuel for two-cycle engine _____.
 - overheating may result
 - spark plugs may become overheated
 - incomplete combustion may occur
 - seizing will result
- Filler caps with screw vents are for the purpose of _____.
 - preventing fuel evaporation when closed
 - preventing fuel starvation when open
 - preventing contamination in the tank
 - All of the above.
- The two types of fuel pumps discussed in this chapter are _____.
 - atmospheric pressure and gravity vacuum
 - impulse diaphragm and mechanical
 - gravity vacuum and mechanical
 - gravity vacuum and impulse diaphragm
- When a carburetor has been removed and replaced, the engine will be slow starting because of lack of fuel. This problem can be overcome if the engine has a fuel pump with a(n) _____.

- One satisfactory fuel system that prevents vapor lock is the _____ system.
- CARB stands for _____.
- Stricter requirements needed in the future may cause manufacturers to resort to equipping their engines with _____ converters and fuel _____.
- What are the three major pollutants from exhaust fumes?
- Spillage of gasoline during refueling operations produces what is called _____ pollution.
- Estimated refueling losses due to spillage equate to about _____ million gallons of gasoline.
- Spillage of gasoline contributes to ground level _____, a component of smog.
- What two categories do regulated equipment fall into?
- The new cleaner running engines will require consumers to follow manufacturer's suggested _____ to reduce pollution and retain good performance.



Suggested Activities

- Collect a variety of tank filler caps. Either cut them in half or disassemble them. Make a display board showing the baffle and the filter system.
- Make a display board of cutaway drawings of fuel tanks with gravity feed fuel lines and top mounted pick-up lines.
- Obtain and cut away some old fuel pumps so that internal parts can be seen and operated. Note the function and location of each internal component.
- Cut away parts of an old fuel filter so that the fuel circuit can be traced.
- Demonstrate proper methods of engine fueling that will minimize spillage of gasoline. Use a standard fuel can and filler nozzle. List equipment and/or methods of improving the procedure, such as those shown in **Figure 7-20**.