SMALL ENGINES 2

Teacher's Guide

TVOntario

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This guide is designed to accompany the television series Small *Engines 2*.

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Teacher's Guide to Accompany
Andrew Marquette's SMALL ENGINES 2

A ten program introduction to two-stroke-cycle small-engine operations, and the maintenance, repair, and storage of typical machines in which they are found.

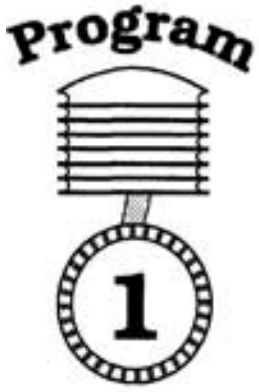
Introduction

This ten-part program is the second in Andrew Marquette's popular series on small engines. The first series introduces four-stroke-cycle small engines and their maintenance, repair, storage, and use. This second series covers much the same **ground for two-stroke-cycle** small engines and their typical applications, with a particular focus on snowmobiles, outboard motors, all-terrain vehicles (ATVs), chain saws, and water pumps and generators. Popular machines are used to illustrate servicing, maintenance, and storage procedures,

Each program in this ten-part series is less than fifteen minutes long, making its subject matter easy to absorb. Topics are presented in a lively manner, including interviews with users of typical two-stroke-cycle machines. The tools and materials needed to undertake the operations discussed are common to most workshops. The one significant exception, the flywheel-holding tool, can easily be fabricated for a few dollars in any welding shop.

As with the first series, this ten-part series on two-stroke-cycle small engines will appeal to diverse audiences. High school students, cottagers, farmers, resort operators, apprenticeship mechanics, and people in many other walks of life can enjoy these programs and learn from them. All operations are conducted in a logical and systematic way that ensures success. The first five programs cover two-stroke-cycle engine operation, disassembly and assembly, troubleshooting, and basic servicing and storage. The last five programs offer more specific advice and helpful hints on the maintenance, storage, and safe operation of snowmobiles, outboards, ATVs, chain saws, and water pumps and generators.

The following notes have been prepared to assist teachers who are basing a course in part or in whole on the programs in this series. The procedural elements and questions, however, are written so they can be used by students as well. At the end of this series, students should be well-equipped with the basic knowledge and skills needed to service most two-stroke-cycle small engines and maintain and store them in good working order. They will also be ready for more advanced work.



Two-Stroke-Engine Operation

Introduction

Two-stroke-cycle small engines typically power outboard motors, snowmobiles, water pumps, generators, chains saws, all-terrain vehicles, and lawn mowers-machines which are popular and particularly useful in rural and unpopulated areas. Although they work on the two-stroke cycle, the small engines in these machines frequently employ different features, depending on their application and the environment in which they are used. Outboard motors, for instance, have features that allow them to be water-cooled, whereas water pumps and chain saws have features that allow them to be air-cooled.

This initial program looks at the operation of two-stroke-cycle engines and how this operation differs from that of four-stroke-cycle engines. Cutaway engines are used to review four-stroke-engine operations and to illustrate the unique features of the two-stroke cycle engine and the steps involved in its operation.

Four-Stroke-Cycle Engine Operation

To begin, have students review the intake, compression, power, and exhaust strokes of a four-stroke engine and the opening and closing of its intake and exhaust valves in tandem. Use a cutaway engine to illustrate, if available. Emphasize the fact that the crankshaft must turn two revolutions (720°) to complete each cycle, and that the piston moves from TDC to BDC, or from BDC to TDC, to complete each stroke.

Engine Systems

Both engines rely on the following five basic systems to operate:

- fuel (tank, gas lines, fuel filter, carburetor, etc.)
- ignition (spark plug, ignition wires, recoil magneto or electric starter, etc.)
- cooling (fins, shroud, and fan vanes, etc., on air-cooled engines; water pump and jacket, etc., on water-cooled engines)
- exhaust (muffler, manifold, etc.)
- lubrication (oil, etc.)

Four- and two-stroke-cycle engines differ markedly in their lubrication systems, as explained below. The other systems are structured and work much the same regardless of engine type.

Two-Stroke-Cycle Engine Operation

On a two-stroke-cycle engine there are only three moving parts: the piston, its connecting rod, and the crankshaft to which the rod is connected. Instead of valves, two-stroke engines employ carburetor (intake), transfer, and exhaust ports to add the fuel mixture to the cylinder and exhaust the burnt gases. Only two piston strokes, i.e., from TDC to BDC and from BDC to TDC, are needed to complete the intake, compression, power, and exhaust cycle. The crankshaft thus turns only once (360 degrees) per cycle.

Use a cutaway engine or a drawing to illustrate how the two-stroke-cycle engine works. Point out how the area both above and below the piston is utilized, whereas in a four-stroke engine only the area above the piston is used. The operation of the two-stroke-cycle engine shown in the program can be summarized as follows:

BDC to TDC The fuel mixture above the piston is compressed as the piston moves up and seals off the ports. The piston's upward movement creates a low pressure area in the crankcase beneath it. As the piston nears TDC the. carburetor or intake port is uncovered, causing a new surge of fuel mixture to be drawn through it from the carburetor to fill the partial vacuum in the crankcase. Compression and intake, in other words, happen in the same stroke. This capacity to do two things at once represents the major difference between two- and four-stroke-cycle engines.

TDC to BDC Power and exhaust both take place during this stroke. At TDC the spark plug ignites the compressed mixture. The burning, expanding gases that result force the piston downwards, recovering the intake port and partly compressing the fuel mixture in the crankcase, an action known as primary compression. As the piston nears BDC it uncovers the exhaust port, allowing the spent gases to escape. At BDC the transfer port opens and the pressurized fuel mixture rushes into the area above the piston. The piston then begins moving upwards to start the cycle over again. The cycle continues until the engine is turned off or runs out of fuel.

Summary of Differences

Aside from the two-stroke cycle, the main differences between two- and four-stroke-cycle engines can be summarized as follows:

- Two-stroke engines employ ports instead of valves.
- Since they do not have valves, two-stroke engines have no camshafts.
- Two-stroke engines do not have an oil reservoir in the crankcase, as oil is either mixed with the fuel or is injected into the crankcase from a separate oil tank.
- The crankcase in two-stroke engines is smaller to enable piston action to create primary compression. *Note: Some engines use a reed or a rotary valve in place of the intake port illustrated to transfer the fuel mixture to the crankcase. What is shown as the transfer port is then known as the intake port.*

Lubrication

Instead of an oil reservoir in the crankcase, two-stroke engines are typically lubricated by mixing a set ratio of oil into the gasoline to be added to the fuel tank. This ratio is typically one part oil to 25 or 50 parts gasoline. *Caution! The correct mixture and proper oil, as described in the engine manual, must be used or engine damage can result. You* can show students what such a mixture looks like by preparing one in a clear container. *Cautton! Remind students that what you are doing is strictly a demonstration, and that only approved containers should be used for mixing and storing fuel.*

Other two-stroke engines employ a separate oil tank from which the correct amount of oil is automatically injected directly into the crankcase. In such cases, the caps for the gasoline and oil tans must not be confusedl

Review

Review the main differences between two- and four-stroke engines, and two-stroke engine operation. Students will be interested to know that two-stroke engines produce twice as much power as four-stroke engines of the same size and mass, but typically consume more fuel and produce more pollutants. See if they can reason why.

Check Your Knowledge

1. Name four typical applications for two-stroke-cycle small engines.
2. What happens in a two-stroke engine when the piston travels from BDC to TDC? What about from TDC to BDC?
3. Name and explain four other main differences between two- and four-stroke engines.
4. What are two ways in which small engines can be lubricated?
5. Why isn't a camshaft used in two-stroke engines?

Two-Stroke Engine Disassembly

Introduction

If a four-point check determines there is insufficient a) fuel, b) spark, c) compression, or d) lubrication, some level of engine disassembly may be required. Evidence of insufficient lubrication, for instance, might be reason for a disassembly that in turn revealed a damaged, scored piston in need of replacement. As with four-stroke engines, two-stroke engines must be disassembled systematically. Although complete engine disassembly is seldom necessary, it is undertaken in this program to help students understand how the various parts and systems that make up a two-stroke engine function together, and to learn each stage in the procedure. The following disassembly sequence is based on the Rotax snowmobile engine used in the program.

Disassembly Sequence

Step 1 Drain the fuel in the engine (and from the fuel tank, if attached) into an approved gasoline container. An approved container is color-coded red for danger, and is designed to contain fuel vapors as well as liquid fuel, as gasoline fumes are potentially explosive and dangerous to breathe. Disconnect the fuel line from the carburetor and plug it so fuel does not leak out, then disconnect the carburetor and drain it as well.

Step 2 Remove, in sequence, the recoil and the main shroud by ratcheting off the bolts that hold them in place on the engine block. Place the bolts in a container or other secure place so they cannot get lost. The shroud is an important part of an air-cooled engine's cooling system. With the main shroud off and the spark plug removed, pull the recoil cord to demonstrate how the vanes on the flywheel push air up and around the inside of the shroud and over the engine's heat-dissipating fins, when the engine is running. This constant flow of air removes excess heat from the engine.

Step 3 To remove the flywheel, first remove the pull-start mechanism that attaches to the flywheel and links it to the recoil, along with the flywheel nut cover underneath. The bolts that hold both in place are easily removed with a socket and extension. Then use a bracing tool like the one shown in the program (easily fabricated in a welding shop) to hold the flywheel so it will not turn while you loosen and remove the flywheel nut with a socket and socket drive.

Now put the bracing tool to one side and screw a suitable flywheel puller onto the threaded flywheel centre. Place a socket over the puller nut and proceed to "pull" the flywheel towards you by tightening the nut with a socket drive. This action creates an even force that actually pushes the flywheel forward without damaging it or the crankshaft.

Remove the flywheel and the flywheel key inside, noting the keyway in the crankshaft and flywheel. The key is an integral part of the ignition system, as it causes the flywheel to rotate with the crankshaft. Without the key the engine will not run. With the flywheel removed, you can now take off the rear shroud by removing its attaching bolts.

Step 4 Begin removing the cylinder head by completely loosening off the cylinder head nuts, using a socket and T-handle drive. *Note: This procedure is only possible after all parts listed in, the steps above have been removed.* Lift the head straight up off its bolts (this may require some effort), and tap it gently upside down on a table to dislodge the nuts and washers. Store them in a container or other secure place.

Carefully lift up and remove the cylinder head gasket. Check it for cracks, breaks, or other flaws that could cause it to seal imperfectly and cause engine compression to escape. Now is a good time to point out the multiple functions of the cylinder head, i.e., it houses the spark plug, forms the combustion chamber, and acts with the gasket to contain compression. It also forms the

engine's most important cooling fins, as the combustion that takes place immediately underneath the head makes it the hottest part of the engine.

Step 6 Move the piston to BDC, then remove the cylinder by lifting it very carefully straight up and off the piston. The piston rings will snap audibly as the cylinder is removed. Notice the cylinder's bore, the cooling fins cast into its sides, and its exhaust and intake ports. Check the gasket that seals the cylinder to the crankcase for cracks, breaks, or other flaws. If this gasket leaks, the crankcase will not be sealed. The engine will then run too lean and be at risk of seizing and "burning up".

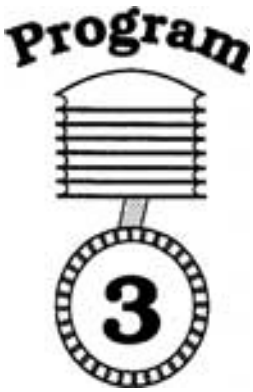
Step 6 Finally, examine piston operation and condition. Check the piston pin that attaches the piston to its connecting rod and allows the piston to travel up and down in the cylinder. Check the connecting rod for proper function. Carefully inspect the piston rings and grooves for damage, noting the small pin in each groove that keeps its ring from turning. Broken or worn rings will cause compression to be lost from the cylinder, and must be replaced. Pistons with worn grooves or warped skirts should also be replaced.

Review

Briefly review the systematic steps in two-stroke engine disassembly, i.e., 1) drain the fuel, 2) remove the recoil and main shroud, 3) remove the flywheel and back shroud, 4) remove the cylinder head, 5) remove the cylinder, and 6) examine piston operation and condition.

Check Your Knowledge

1. When is it necessary to disassemble a two-stroke engine?
2. Name at least three places where fuel can be found in a two-stroke engine.
3. What would likely happen to an air-cooled engine run without its shroud?
4. How does a flywheel puller work?
5. Why is it important that the gasket between the cylinder and the crankcase not leak?
6. After what step and before what other step is the cylinder head removed?



Two-Stroke Engine Assembly

Introduction

In this program, the same Rotax engine is reassembled. Ask students to think about the order in which parts will have to go back together before they view the program, reinforcing the need for systematic work. Additionally, impress on them the need to follow these strict rules:

- All parts must be clean; no dirt must get into the engine.
- All moving parts must be lubricated before reassembly.
- Service manual instructions and specifications must be followed.
- Special tools (i.e., feeler gauge, torque wrench, and flywheel brace) must be used when required.

Reassembly Sequence

Step 1 Begin by replacing the cylinder. First, however, check the gasket that acts to seal the cylinder to the crankcase, and replace it if it looks damaged. A leaking gasket can cause the engine to run lean and the piston to seize in the cylinder. Then position the cylinder on its *mounting bolts with the cylinder's carburetor port in line with the engine's ignition. Caution! If either the cylinder or its cylinder head is replaced incorrectly, the engine will have to be taken apart and reassembled again when the error is discovered.*Place the piston at BDC and gently lower the cylinder until it sits on top of the piston rings.

This next task is the trickiest part of reassembly. Using a whittled-down popsicle or similarly thin stick, push the edges of each ring on which the cylinder sits, in turn, inside the cylinder. *Caution! Don't use metal items for this task, as they may score the piston.* Alternatively, a piston-ring compression tool can be used. When the rings are inside, the cylinder will drop gently down to seat on the gasket.

Step 2 Wipe the inside of the cylinder clean, lubricate its walls with engine oil, and distribute the oil evenly with a clean index finger. Check to be sure the piston moves up and down freely in the cylinder. Determine that the cylinder head gasket is sound and will hold compression, then replace it or substitute a new one. Carefully align the cylinder head so the outer perimeter of its cooling fins matches the perimeter of the cylinder's cooling fins, and lower the head in place.

Replace the washers and nuts over the mounting bolts and tighten the nuts down by hand. Consult the engine's service manual to determine the torque that should be applied for final tightening. Set a torque wrench to half this level and tighten the nuts accordingly, working in a cross-cross fashion. Then set the wrench to the full torque value and repeat the procedure. *Caution! If this technique is not strictly followed the cylinder head or its gasket may warp later on, necessitating major repairs.* Once the engine is fully reassembled, let it run for fifteen or more minutes before torquing it again to eliminate any changes caused by engine heat expansion.

Step 3 Reattach the rear shroud with its lock washers and bolts.

Step 4 Check the magneto ignition and replace the flywheel. A magneto ignition system consists of two coils (inductors), a condenser, a set of points, and a strong permanent magnet (typically located on the flywheel). As the magnet rotates, it induces a current in and magnetic field around the primary coil. When the points open, this magnetic field collapses to induce a high voltage current in the secondary coil, which jumps across the spark plug electrodes to ignite the fuel-air mixture. Make sure the points are not worn or burned, and that the magneto's electrical contacts are firm.

Two items must be carefully fitted when replacing the flywheel. First, the flywheel keyway must fit over the crankshaft key. Second, the cam-like extension located inside the flywheel opposite the keyway must fit into the notch in the edge of the saucer-shaped unit mounted behind the crankshaft key. This saucer-shaped unit rotates to open and close the points, while the key drives the flywheel. Even though it may take a few tries to accomplish, the engine will not run unless both are properly in place.

Afterwards, replace the flywheel nut, use the bracing tool to prevent the flywheel from turning, and torque the nut down to the specifications listed in the engine manual.

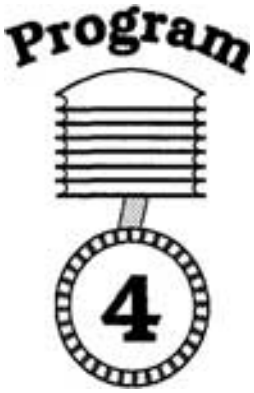
Step S Begin completing the reassembly by reattaching the flywheel nut cover, the pull-start mechanism, the main shroud, and the recoil. Then inspect the carburetor gasket, and place it or a new gasket, as required, in position over the carburetor port in the cylinder. Remount the carburetor and tighten it down, then reconnect the fuel line to the crankcase. Inspect the spark plug and substitute a new one if necessary. Gap the plug according to the engine's specifications with a feeler gauge, and use a spark plug socket to screw it into the cylinder head just firm. Reattach the spark plug wire, and the reassembly is complete.

Review

Ask students to explain why reassembly must be performed in the sequence listed. Review the four rules listed in the introduction, and the cautions given in the steps above.

Check Your Knowledge

1. Why is the gasket seal between the cylinder and the crankcase especially critical?
2. Describe the correct way to tighten down a cylinder head. Why would you torque the head again after operating the engine?
3. What two items must be carefully fitted when reattaching the flywheel? What will be the effect on the engine if this is not done?
4. What parts should be lubricated during reassembly? Why?



Two-Stroke Engine Troubleshooting

Introduction

Every small engine operator has heard of the frustration of dealing with an engine that quits or just won't work when needed. Good maintenance and proper storage help to prevent such disappointing "downtimes". Nevertheless, the wise operator wants to know a thing or two about troubleshooting, the subject of this program. Troubleshooting always starts with the four-point check and the knowledge that the vast majority of problems, whether on two- or four-stroke engines, are fuel or ignition related. Loss of engine compression, while less frequent, can cause power loss or more serious problems. Lack of lubrication, while very serious, is usually quickly noticed and remedied, and so is not covered here. The following diagnostic advice is based on a snowmobile.

Troubleshooting the Fuel System

Step 1 Check the fuel tank. If no fuel is present but the gauge indicates otherwise, check the fuel float (or other fuel indicator) to see that it moves or otherwise registers freely. Does the gauge indicator move in tandem? If not, you're likely getting false readings that can run you out of gas.

Step 2 Briefly smell the gas. *Caution! Gasoline fumes are poisonous, explosive, and carcinogenic!* If the odor is off, the gas is old and should be replaced. Improperly stored gas will absorb water vapor from the air, and also spoilage organisms. When used such gas can cause poor combustion, cylinder and piston head damage, knocking, and winter gas-line freeze-up. Old, exposed gas may also "gum up" or harbor dirt that can clog the gas line or pass through to score the cylinder walls. For this reason alone, always use a screened funnel when adding fuel.

Step 3 Check to be certain that the fuel and oil tank (if present) vents are clean, and that the fuel, oil, and carburetor lines are clear and unblocked.

Step 4 Check the fuel filter to see if it is clogged or dirty. If it is, it will impede or stop gas from flowing to the carburetor.

Step 5 If you're still not certain that fuel is reaching the carburetor, remove the engine spark plug, disconnect the carburetor fuel line and hold it over a container, and crank the engine a few times. *Caution! Always keep feet away from hot engines.* If fuel doesn't splutter into the container, the carburetor may be blocked. Take the engine back to your dealer or a qualified mechanic.

Troubleshooting the Ignition System

Most modern snowmobiles and ATVs have electronic ignition systems that provide better spark than simple magneto ignitions. Problems with such systems may not be obvious, and may have to be referred to a dealer or qualified mechanic. Still, there are many ignition problems that the operator can determine and repair.

Step 1 Remove and inspect the spark plug(s). The electrodes should be brown to grayish tan, with little wear. An oil-fouled (oily) plug indicates too much oil in the fuel oil mixture, while a blackened plug indicates an over-rich fuel oil mixture, or weak ignition. Correct the problem before cleaning, regapping, and replacing the plug(s).

If the engine is being flooded when starting, plug electrodes will be discolored and burned, or even wet. Depending on the condition, these plugs may be reused. Plugs with corroded, burnt, pitted, or melted electrodes, or with cracked or broken insulators should be discarded. The former conditions can be caused by running an engine too hot, or by using plugs whose heat range

Is incorrect. Check the service manual to find out the size and heat range of the plug(s) you should be using. The numbers on the porcelain insulator of each plug typically indicate its size and heat range.

Step 2 Check for spark by removing a spark plug and attaching it to its spark plug wire and turning the "kill" and ignition switches on. Then hold the plug by its wire so its ground electrode is in contact with the engine block, and turn the engine over. Caution! Never undertake this procedure near spilled or open fuel! If not done correctly, electronic ignition system damage may result. The spark should be bright blue. If there is no spark, or if the engine is multi-cylinder, try another plug. If you get the same result after checking the connections and switches, have the ignition system examined by your dealer or an ignition specialist.

Troubleshooting Engine Compression Loss

Loss of compression can cause loss of power and lead to more serious problems if not corrected quickly.

Step 1 A general compression loss test can be performed anywhere by removing the spark plug, putting one thumb over the plug hole, and turning the engine over briefly. A distinctive popping noise indicates compression is present.

Step 2 To determine exactly how much compression is present, mount a compression gauge in the spark plug hole, crank the engine over, and read out the cylinder compression on the gauge dial. Compare this value with the cylinder compression level specified in your engine manual. Most small engines are designed to build around 700 kPa (100 p.s.i.) of pressure. Any reading significantly below this level, which could be caused by worn rings, a hole in the piston, a warped cylinder head, or a blown head gasket, indicates the need for remedial action. The procedure could be as simple as retorquing the cylinder head on a new engine, or could involve disassembly.

Review

To work, an engine needs a steady supply of clean air and fuel, sufficient compression, good spark, and lubrication. When any one of these four elements is missing or inadequate, the engine will not run properly if at all, and troubleshooting is in order.

Check Your Knowledge

1. What two systems account for the great majority of small engine problems?
2. What can happen to improperly stored gas that can make it unsuitable for engine use?
3. Describe the probable appearance of spark plug electrodes from a) a properly running engine, b) an engine running too lean, c) an engine running too rich, and d) an engine that frequently floods during starts.
4. Name four conditions that can lead to a loss of cylinder compression.

Servicing and Storing Two-Stroke Cycle Engines

Introduction

The first part of this program briefly reviews several core maintenance principles and safety rules. The second part covers servicing and maintenance tips that will help the small engine operator to store his or her machines properly during the off season.

Maintenance-A Question and Answer Review

Q. *What precautions must be taken at each reassembly stage?*

A. Parts must be clean, and moving parts must be lubricated before reassembly. Dirt in the engine will cause cylinder and piston scoring and wear, as will unlubricated parts.

Q. *What is the signifcance of blue exhaust smoke?*

A. In the case of a four-stroke engine, blue exhaust indicates that oil is getting past the piston rings and burning with the fuel. The rings, piston, and cylinder may all need attention. A two-stroke engine's exhaust is naturally light blue because it is designed to burn some oil. If the color is thick or excessively blue, it may mean that too much oil is present in the fuel mixture, or that the rings are worn.

Why do we need torque wrenches?

A. Torque is force that acts in a twisting or circular fashion. Every nut, washer, and bolt, and each rotating engine part is designed to withstand only so much torque. Critical torque values are usually listed in each engine manual.

Q. *Why are gaskets important?*

A. Gaskets are used to seal adjoining engine parts against compression or other leaks. Defective gaskets can cause loss of power, fuel, and lubrication, and serious engine damage.

Why is the -flywheel so important, and how is it driven?

A. The flywheel helps the crankshaft turn evenly and smoothly between power surges, forms part of the engine's cooling system, and keeps engine strokes in time. The flywheel is driven by a key in the crankshaft. If this key is bent or broken, the engine will not run correctly, if at all.

Q. *What are the main dtfferences between two- and four-stroke engines?*

A. A two-stroke engine has ports instead of valves and therefore lacks a camshaft, utilizes the space both above and below the piston for compression and fuel delivery, and employs a smaller crankcase without an oil reservoir. Oil is either added to the gas or is injected into the engine crankcase.

Safety Rule Review

1. Store fuel in approved containers only. Fuel is explosive, flammable, and dangerous to breathe.
2. Guard against spontaneous combustion by storing oily rags in a metal container with a tight-fitting lid.
3. Always have a full, Class-B-fire-approved (liquids) fire extinguisher handy where you plan to work on small engines.

4. Don't wear rings or jewelery, and eliminate loose clothing, hair, and other features that could catch on machinery and lead to serious injury.

5. Guard against fire, toxic vapors, and sudden slips by cleaning up fuel and oil spills immediately.

6. Never run an engine indoors or without adequate ventilation.

7. Never refuel a hot engine, particularly a chain saw, as hot surfaces may ignite spilled fuel. With similar concern, never check for spark in the presence of spilled fuel.

Two-Stroke Engine Maintenance and Servicing Prior to Storage

A small engine that is properly maintained and serviced prior to storage is safe and ready to go, when needed. In fact, if you practise these simple maintenance steps regularly and not just when you need to store your engine, it should start and run trouble-free. Items and systems that should be checked include the spark plug, air cleaner, carburetor, starting system, lubrication system, gas tank, and exhaust system.

Step I Remove and check the spark plug for fouled, burnt, or pitted electrodes, chipped insulation, and proper gap. Check the engine if the plug's condition indicates, and substitute a new plug if necessary.

Step 2 Check the spark plug wire and connector for broken insulation, and make sure there is good contact at the coil.

Step 3 With the spark plug removed, place a few drops of oil inside the cylinder and turn the engine over a few times to prevent the cylinder and piston head from rusting in storage. Replace the spark plug, when finished.

Step 4 Check the air cleaner for dirt, clogs, and rips, and clean or replace it as necessary. *Note., Outboards, snowmobiles, and some other engines do not have air cleaners.*

Step 5 Be careful not to touch its idle circuit or its other adjustments, when draining the carburetor of fuel.

Step 6 Now check the complete fuel system. Drain the fuel tank and be sure it is securely mounted where it will not rub against some other part of the machine during engine operation. If it does, a hole may wear through the tank and cause it to leak, creating a dangerous situation. Check the vents in the fuel cap and clean them if necessary.

Carefully inspect the fuel lines for cracks, especially where they connect to the fuel filter, carburetor, and tank. They should attach securely, without kinks. Remove any dirt or grit that could block or restrict the fuel filter, making sure that fuel will flow through it unobstructed after it is cleaned. On engines so equipped the nearby oil injection lines should appear reddish, indicating that they are flowing oil.

Return to the carburetor and inspect the throttle cable to be sure it is securely attached and not kinked. The cable must move freely; otherwise it may stick open, creating a potentially dangerous situation as the engine "overrevs".

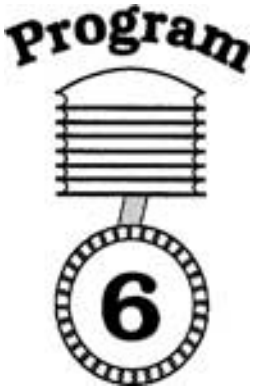
Step 7 Examine the exhaust system, starting with the springs that hold the exhaust in place. Then remove the exhaust pipe and check the exhaust port for carbon build-up. Use a small wooden stick to remove any excess carbon. Lastly, check the exhaust pipes and replace any that are cracked or well rusted.

Storage

Check again to be absolutely certain all fuel has been drained from the system, then store the engine or machine in a cool, dry area and cover it.

Check Your Knowledge

1. What are two possible reasons for the presence of blue smoke in two-stroke engine exhaust? What might be the reason for its presence in four-stroke engine exhaust?
2. Why should you never refuel a hot engine?
3. Your storage inspection reveals an air cleaner with a reasonably clean element but a rip in its plastic frame. What should you do?
4. What do you want to put down the spark plug hole before you replace the spark plug, and why?
5. What can happen to an engine if its throttle cable is kinked?
6. Name two reasons why all fuel should be drained from an engine prior to storage.



The Snowmobile

Introduction

The snowmobile is one of Canada's best known and most important inventions. It has transformed life in the cold regions of the world. Borne of a desire to travel dependably and quickly over frozen terrain, the snowmobile gets us to places our ancestors could only arrive at in dreams, or through courage and great privation. Although Louis Bombardier intended his vehicle as a utilitarian, hazard-avoiding device, its greater use today is probably recreational.

Safety

The increased mobility and range that the snowmobile gives us must always be tempered by the dangers of frost-bite and death from exposure in the case of mechanical breakdown, accident, or operator error. Important snowmobile safety tips to follow before each trip include:

Check the vehicle thoroughly to be sure everything is in top working order. Your life may well depend on it. Be certain the lights and brakes are working properly, and that the fuel tank is full.

- Pack a survival kit and a blanket.
- Tell someone where you are going and when you'll be back.
- Dress properly and warmly, and wear a helmet.
- Know and operate your vehicle within the standard rules of snowmobile safety.

Maintenance

Carry out maintenance procedures on your snowmobile in your shop or garage. The track, suspension, steering and skis, engine, drive train, brakes, and electrical system should be inspected at regular intervals. A one-cylinder, air-cooled, Polaris snowmobile is used in the program.

Step I Check the track and rear suspension. The track must be properly aligned and set at the right tension. Follow the instructions given in your vehicle's manual. Also check the sliders, which are always in contact with the track, for excessive wear and replace them, if necessary.

The rear suspension consists of springs and shock absorbers that cushion the ride. Inspect the springs for cracks and the shocks for oil leaks. Replace any parts so affected.

Step 2 Check the front suspension and steering components, starting with the skis and wear bars. Steering control is greatly hampered by worn wear bars, so they should be checked frequently and replaced as soon as wear is obvious.

Most new snowmobiles have independent front suspension, i.e., a separate spring and shock absorber for each ski. Check for cracks and leaks, and replace defective parts.

Check the tie rod ends next, and lubricate them as necessary. If the ends are worn, they must be replaced. Then consult your vehicle manual for the proper ski toe-in, toe-out settings, and check and realign your skis as necessary.

Step 3 Check the engine. All snowmobile engines are two-stroke and use oil-injection, and so have a separate oil tank, but some are air-cooled while most are liquid cooled, and some have but one cylinder (as shown in the program) while others have two, three, or four. Many newer machines have electronic fuel injection in place of a carburetor. If the one you are Inspecting has a recoil start, examine its cord for frays and wear. If you find the slightest flaw, replace

the cord for safety's sake. A broken cord "out there" means an engine that won't start, and a frigid, lengthy, dangerous walk home.

Now conduct a four-point check to be sure the ignition, compression, fuel, and lubrication systems and components are working properly.

- ✓ Check for spark by removing the spark plug, reattaching the spark plug wire, placing the ground electrode in contact with the engine block, and cranking over the engine. Caution! *Hold onto the wire, not the plug. Never check for spark near open fuel containers or spilled fuel!*
- ✓ Check for compression using the quick thumb test or a compression gauge.
- ✓ Check for fuel by inspecting the tank, fuel lines, and fuel filter.
- ✓ Check for lubrication on oil-injection engines by looking for oil in the oil tank and the oil lines, and by ascertaining that oil is getting to the engine. *Note: When* ***filling the oil*** *tank be sure to use the oil recommended by the vehicle manufacturer.*

Step 4 Examine your drive train to be certain your belt(s) or chain(s) is/are not worn. Replace any defective parts. *Note: The snowmobile in the program uses a direct drive system with a single belt.* Consult your vehicle manual to determine the type of drive train your vehicle *employs.*

Step 5 Check the brakes for wear, rust, and scoring, and have them serviced or replaced as necessary, referring to your manual for proper specifications. Look for kinks in the brake cable or other blockages which may impede its free movement, and either remove them or replace the cable. Lubricate the cable so it will work freely.

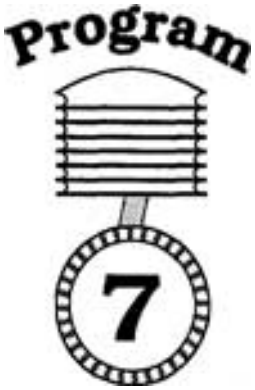
Step 6 Check the electrical system. Start by checking the headlights, tail lights, brake lights, and switches to be sure they are operational. Then inspect the electrical starter and battery on vehicles so equipped, or the recoil. Check the wiring for kinks or broken insulation and the contacts to be *sure* they are tight and clean. Disconnect any corroded terminals, sand them clean, and reconnect them. Finally, re-examine the wires to be certain they are correctly positioned and secured where they will not be damaged.

Storage

Before storing a snowmobile, drain all fuel out of the tank, engine, and carburetor. Then remove the spark plug(s), squirt a small amount of oil inside the cylinder, turn the engine over a few times to distribute the oil evenly, and replace the plug(s). Further guard against rust by touching up paint chips and painting the skis and underside of the vehicle. To prevent the brake discs (rotors) from rusting, finger-paint them with a little transmission fluid. Lastly, support the machine and its tracks off the ground and cover it to keep out dust and spills.

Check Your Knowledge

1. What are *five* safety tips to follow before any snowmobile outing?
2. Your left front shock is leaking. What should you do?
3. When should wear bars be replaced, and why?
4. How many frays can you allow before replacing the recoil cord? Why?
5. What steps would you take to guard against rust when storing a snowmobile?



❑ Outboard Motors

Introduction

The water-cooled outboard motor has become the essential means by which to propel small boats in lake and river country for leisure activities, work, or transport. At the heart of most outboard motors is a two-stroke engine. The 25 hp (18.6 kW) two-cylinder Mercury outboard used in the program is fairly typical.

Safety

Like the snowmobile, the outboard motor can quickly take us long distances from base. Should the engine fail in such circumstances, we could face an arduous journey home or even death from exposure or drowning. Operator error and foolishness also cause many tragedies. Safety tips to follow before each boating trip include:

- Verify that the outboard is mounted correctly and is in good working order, with enough fuel to easily get you where you plan to go and back. Your life may depend on it.
- Never set out without an approved life jacket on each passenger, a pair of oars, a bailer, and a patch kit.
- Dress warmly and pack rainwear, maps, and a compass.
- Tell someone where you're going and when you'll be back.
- Don't set out in foul weather. If you see a storm brewing, head for shore and wait it out.
- Know and follow standard rules of boating safety.

Maintenance

An outboard that is well maintained will give you many years of dependable service and peace of mind. A poorly maintained outboard is a nuisance and a potential safety hazard. Outboards are usually divided into the *powerheacl,* which includes the engine, and the *lower unit,* which houses the gears, drive shaft, water pump, propeller shaft, and propeller.

Because outboards are water-cooled, their engine cylinders are surrounded by a water jacket instead of fins. The water pump in the lower unit pumps water up from the surrounding lake or river through the water jacket. This water picks up excess engine heat and is then discharged back into the river or lake through a water port. This water is visible as a discharge stream, when the engine is running.

Step 1 Begin by removing the upper cowling from the outboard's powerhead.

Step 2 Check the ignition system starting with the coil and the spark plug wires. Inspect the wires that connect to the coils for frays or breaks in the insulation, and replace them as necessary. Examine the condition of the spark plugs and clean or replace them, as needed. Consult the engine manual for correct spark plug gap, and use a gapping tool like the one shown to check and/or correct the gaps as necessary. The tool should just drag between each plug's electrodes when they are properly gapped.

Step 3 Inspect the fuel system. Make certain the fuel hoses running to the carburetor and from the fuel tank are not brittle or cracked, and that their fittings are tight. Then check the fuel filter or pump for dirt inside the bowl or filter that could starve the engine for fuel and prevent it from running. If dirt is present, remove the filter or bowl, wash it out with gasoline, and let it dry before replacing it. *Caution) Perform this operation away from any source* of *flame, high* heat, or spark. Afterwards, replace the cowling.

Step 4 Position the outboard upright. Then check the gear oil in the lower unit by using a screwdriver to loosen off the top oil plug located above the propeller on the side of the drive train housing. If oil begins running out, the oil level is sufficient and the plug should be quickly replaced.

If not, or if the oil is due for a change, fully remove the top plug and unscrew the lower drain plug (located below the propeller in line with the top plug) and let the old oil drain into a container. Look for excess dirt, grit, or metal filings in the used oil. Excess dirt and grit can cause gear wear, leading to metal filings that clearly signal that the gears are grinding. Note: *Changing the oil regularly according to the manufacturer's recommendations could prevent these problems.*

Replace the drained oil with the manufacturer's suggested lubricant. Cut off the end of the lube tube and screw it into position in the lower drain plug. Squeeze the tube, working from the bottom to its top, to force the oil up into the gear case towards the top plug hole. You will be able to hear the oil rise as this is done. Note: *The oil must be replaced in this manner* to *prevent air pocketsfrom being trapped inside the gear case.* When oil starts coming out of the top hole, quickly unscrew the lube tube and screw in the bottom plug, followed by the top plug, and snug both up. Expect to lose a bit of oil.

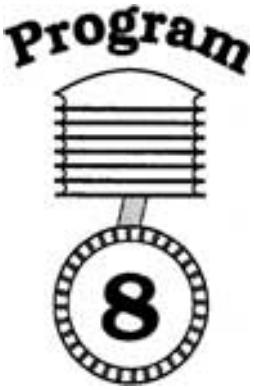
Step S Lastly, check the propeller. Undo any cotter pin in its retaining nut and loosen off the nut with a wrench, then pull the propeller towards you off its shaft. Examine its fins for damage from hitting rocks, flotsam, and so forth. A damaged propeller must be replaced, as its uneven vibrations will damage the engine.

storage

Drain all fuel from the carburetor. Remove the spark plugs, place a few drops of oil in each cylinder, crank the engine over a few times to distribute the oil, and replace the plugs. Store the outboard in a garage or other enclosed space, and in an upright position so any water left inside can drain. Cover the outboard against dust and spills. *Caution! f the outboard is not stored vertically and allowed to drain, water trapped in the machine may freeze and crack the water cooling components.*

Check Your Knowledge

1. Why is a poorly maintained outboard a potential safety hazard?
2. Describe how outboard motors are cooled.
3. If you find a fuel line with a loose fitting and some dirt in the fuel bowl during regular maintenance, what should you do?
4. Describe the proper manner in which to replace gear oil.
5. Why must outboard motors always be stored upright?



All-Terrain Vehicles

Introduction

All-terrain vehicles (ATV's) have won North America by storm over the last two decades as land-based, summer recreational run-abouts. Pragmatically, however, their value lies in their ability to transport farmers, greenskeepers, utility workers, surveyors, miners, forestry personnel, cottagers, resort owners, and others who live or work close to the land over difficult terrain. Coupled with the snowmobile, boat, and outboard motor, ATV's have given us transport dominion over most of the Earth's surface.

safety

ATV's can easily take us as far afield as a snowmobile or outboard motor. Following proper safety precautions before and during each trip will help to prevent breakdowns and injuries.

- Inspect the vehicle thoroughly. Check the plugs, oil injection lines, cables, lights, and tire pressure. Correct any loose bolts or wires, and make sure the fuel tank is full.
- Wear an approved helmet, goggles, high boots, gloves, and a long-sleeved shirt.
- Tell someone where you are going and when you'll be back.
- Drive the vehicle sensibly. Avoid high speeds, abrupt turns, steep slopes, bogs, and deep or fast water.
- Carry a basic tool kit.

Maintenance

ATV engines may be two- or four-stroke, water- or air-cooled, belt- or chain-driven, and geared to either single- or multiple-speed transmissions. Regardless of their configuration, they will only give good service, if well maintained. The following steps are based on the two-stroke, air-cooled, chain-driven Polaris ATV shown in the program. Students will better understand suspension, drive, and steering components if the vehicle is placed on blocks and the wheels are removed for the first three procedures. To inspect the brakes, wheel removal is a must.

Step 1 Check the rear suspension. Look for leaks from the shock absorber(s) and cracks in the rear spring(s), and replace any parts so affected.

Step 2 Check the drive chain or belt for wear. If it is stiff, rusted, worn, or cracked replace it. Next, check the chain or belt for proper adjustment. It shouldn't lift more than 30 millimeters. If it does, loosen off the two bolts that hold the axle in position and turn the axle mount until the extra slack is taken up, and tighten down the bolts. *Note: The chain or belt tightens because the axle mount is eccentric.*

Step 3 Examine the front suspension, again looking for leaking shock absorbers and damaged springs, and replace any parts so affected. *Note: MacPherson Strut suspensions, as shown in the program, combine shock absorbers and springs into one unit.*

Step 4 Inspect the brakes and steering components. The brake rotors and/or drums should show lots of clean, thick metal, without scoring or rust. Brake pads should not be worn thin. Check the steering rod and tie rod ends for wear by attempting to rotate them by hand. Any excessive free play indicates a component that should be replaced. Before finishing, grease the tie rod ends and all the vehicle's grease fittings. Put no more than one or two pumps of grease into each fitting, or the grease seals may break.

Step S Check each tire's pressure and examine its treads for excessive wear. Worn tires should be replaced. Inflate new or low tires to the vehicle manufacturer's specifications. Reinstall the tires as necessary.

Step 6 Check the front wheel alignment by turning both wheels dead front and carefully measuring the distance between the tire centres, front and rear. Rear-wheel drive ATV's should toe-in 3-6 mm (1/8 to 1/4 inches) at the front tires; front wheel vehicles should toe-out by an equal amount. If you find the alignment out, ask your dealer or a qualified mechanic to adjust it.

Step 7 Examine the electrical system. Start by making sure that all the lights are operational. Then check to be sure the starter system, whether recoil or electronic, is in good working order. *Note: If the kill switch (on electronic starter systems) is in the "off" position, the engine will not start.*

Next, check the battery to be sure the electrolyte (acid-water mixture) is up over the top of the cell plates, or is between the levels marked on the sides of see-through batteries. If the electrolyte level is low, top it up with distilled water. *Caution! Handle batteries carefully. Battery electrolyte contains highly caustic sulphuric acid, which can burn skin and ruin clothes. If you spill electrolyte on yourself, wash the area immediately with lots offresh water.*

Make sure the battery terminals are clean. If not, carefully remove the cables, brush the terminals with a mild baking soda solution, and wipe dry. Replace the red cable on the positive terminal, and the black cable on the negative terminal, and gently tighten them just firm. *Caution! Do not overtighten.*

Step 8 Use the four-point check to examine the engine for operational readiness. Because of the terrains on which ATV's are used, they tend to accumulate dust and overheat. Check and remove dust regularly from the fins on air-cooled engines. Inspect the air and fuel filters frequently as well. As on the Polaris engine shown, the air filter may consist of a coarse primary filter *for* larger grit and a second-stage dry element filter to catch fine particulates. Both can usually be blown clean with compressed air. Afterwards, place a light inside the dry element filter and notice whether you can see the light shining through the filter. If you can't, replace the filter. A dirty fuel filter should be cleaned or replaced as necessary, particularly if you are having fuel system problems.

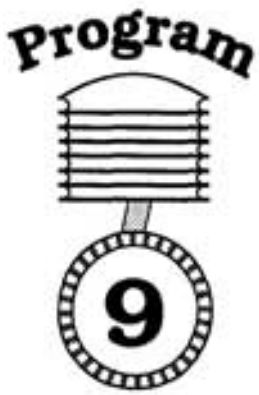
Storage

Find a clean, dry place in which to store the ATV. Drain all fuel from the tank and carburetor, remove the spark plugs, oil the cylinders, and turn over the engine a few times to distribute the oil. Replace the plugs, lubricate all grease fittings, and place the axles on blocks to eliminate stress on the suspension system. Remove the battery and cover the machine against dust and spills.

To store the battery, top up the electrolyte, charge it fully, and store it in the same place. *Caution! Batteries produce dangerously explosive hydrogen gas when they are charging. Keep them well away from any source offlame or spark.*

Check Your Knowledge

1. What safety equipment should be worn when operating an ATV?
2. You find that your drive belt is loose. How do you tighten it?
3. What is the proper amount of toe-out for a front-wheel drive ATV? What type of ATV requires toe-in, instead?
4. Why are ATV's subject to overheating, and what should you do about it?
5. What are two cautions to be aware of when working with batteries?



❑ Chain Saws

Introduction

The chain saw is one of the most widely used tools in rural and unpopulated areas. As the program's lead-in interview with fire-control officer Tony Quedent demonstrates, their portability, ruggedness, light weight, cutting speed, and ease of maintenance make chain saws essential weapons in the fight against forest fires, in this role they are used to fell trees to create helicopter landing pads in the fire area so firefighters and equipment can be brought in, and to clear lines in the forest to stop fires from spreading.

Safety must never be ignored. Work to be cut must be supported firmly above the ground, and cut in such a way that the chain cannot bind. Never position the chain over any part of your body. A hard hat, ear protection, face screen, and gloves are standard safety equipment. Never forget that a sharp chain is a safe chain, and that a dull one can be dangerous.

Maintenance

The maintenance tips contained in this program will help you to keep your chain saw in top working order, ready to go when you need it. Few things are more frustrating than discovering that the machine you urgently need on a job site won't work. To help prevent this turn of events, carry out the following checks at regular intervals. A Jonsered chain saw is used in the program.

Step 1 Begin checking the fuel system by first removing the air cleaner cover and Inspecting the air cleaner. Excess dirt and sawdust can prevent the engine from running or cause it to run rich. Clean or replace the air cleaner as necessary.

Then examine the fuel filter by removing the fuel tank cap and reaching inside the tank to pull out the fuel line and filter attached to its end. Pull off the filter, check it for dirt, and clean or replace it as necessary. If gas is not getting to the carburetor, the fuel filter may be responsible.

Step 2 Check the spark plug for condition and gap. In the chain saw shown, the spark plug is located under the air filter cover. Replace or regap the plug as necessary.

Step 3 Remove and check the recoil cover and its underlying gasket, and the recoil mounted inside the cover. If the recoil cord is worn or frayed, it should be replaced. In addition to the recoil, the flywheel and cooling fan are located underneath the cover. During saw use, this cover frequently fills with sawdust and must be cleaned regularly. If it becomes clogged, the fan may not be able to get sufficient air to cool the engine, which may then overheat.

Step 4 With the recoil cover off, check for additional overheating problems by looking for sawdust on the fan vanes and engine fins. These surfaces must be kept clean for optimum engine cooling to occur.

Step S Check the clutch, chain, and bar by using the wrench supplied with your saw to remove the side cover. Clean away any dirt or sawdust that could interfere with their operation. Also check for blockage of the oil lines under the bar. These lines lubricate the chain to prevent it from drying out and seizing up during use.

The clutch shown in the program works on centrifugal force. With the engine idling, the clutch is not engaged and the chain is not driven. When the throttle is opened, however, the centrifugal force of the added engine revolutions causes masses inside the clutch to be thrown to its circumference. This action engages the clutch and thus drives the chain.

Step 6 Check the chain brake inside the side cover, and clean away any dirt or sawdust that could interfere with its operation. The brake consists of a steel loop that fits over the clutch when the side cover is on. During normal use, a spring holds the loop out of contact with the clutch. In case of an emergency or other problem, however, a forward push on the chain brake

lever attached to the side cover will cause the loop to grab the clutch and stop it and the chain from spinning.

Replace the side cover after this step, but do not tighten down the cover bolts just yet.

Step 7 Check and adjust the chain tension by using a screwdriver to turn the adjustment screw located near where the inside edge of the lower bar enters the body of the saw. Turn the screw so the chain is just snug on the bar. *Caution! Don't overtighten the chain.* When you are finished, tighten up the side cover bolts.

Step 8 Last, sharpen the chain with a suitable metal file. *Caution! To prevent cuts, wear* gloves. Position the saw where it will be stable and the chain easy to get at. The teeth on the chain are cut at about a 35 degree angle, and so should be sharpened accordingly. Use even, upward strokes while holding the file with both hands. When a tooth is correctly sharpened, the file will drag evenly over its surface, producing a clean, rasping sound.

Before beginning, mark a tooth on one side of the chain and sharpen it before sharpening the rest of the teeth on that side. As you work your way around, the mark will show you where you started. When the first side is finished, sharpen the other in the same fashion. After this final step, the saw will be ready for work or for storage until needed. *Caution! Remember that a sharp chain is a safe chain. It will cut cleanly and easily without the need for excessive pressure, and with less danger of kickback. Never work with a dull chain.*

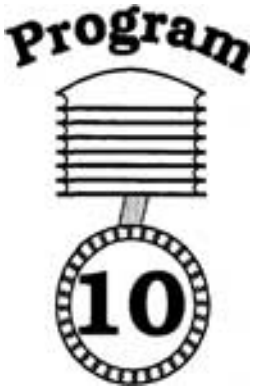
Check Your Knowledge

I. Itemize four safety precautions to follow when using chain saws. What safety equipment should be used?

2. What parts of a chain saw should be regularly checked for accumulated dirt and saw-dust, and cleaned? What can happen if these maintenance steps are not done?

3. Explain the operation of the centrifugal clutch and the chain brake.

4. What is the correct way to hold a file when sharpening a chain? Why is a sharp chain a safe chain?



❑ Generators and Water Pumps

Introduction

This is the final program in the series. Every important aspect of two-stroke small engine safety, maintenance, service, and storage has been touched on at least once by this point. Rather than recover this territory, this program explores the use and operation of two growing and important two-stroke engine applications: gasoline-powered electric generators and water pumps. After viewing this program, students may wish to discuss other two-stroke engine applications, such as lawn mowers, that are not covered in this series.

Electric Generators

The gasoline-powered electric generator has proved a boon to people working at sites where conventional electrical service is not available, such as work sites, farms, and new cottage sites. Rather than put up with the considerable wait and expense that running and installing a new electrical distribution line and service entails, or suffer the dim light of fuel lamps and the inefficiencies and heavy labor of hand tools, they rely on these generators to supply them with the electrical power they need to operate power tools and electric lights as required.

As the program's initial interview with Ontario Ministry of Natural Resources fire-control officer illustrates, electric generators have become a vital tool for work crews in remote areas. More surprising for students may be the realization that these generators also play a critical role in cities by supplying utility and other work crews with power and light as they require it, without the need to tap into and disrupt overhead supplies.

Standard electric generators, like the one in the program, can supply 220 W of power, and typically have AC and DC modes. If you have an electric generator, maintain and store it like you would any other small engine in this series. Be sure to conduct a four-point check a few days before its use is again required.

Water Pumps

Gasoline-powered water pumps have become important tools in the fight against forest fires. They are also used to fill reservoirs in cottage country and elsewhere, drain land, pump out sewers, and in construction and other activities. In use, the powerful two-stroke engines in these machines pump water from a nearby source over gravitational resistance and under pressure to some distant point.

In the program's second interview, an explanation is given of how gasoline-powered water pumps are set up to combat forest fires. The powerful 9 hp (6.7 kW) pump shown in the program can pump 230-270 L (50-60 gallons) per minute at 300 p.s.i. (2070 kPa) over distances up to 730 m (2400 ft.)! The procedure for using such pumps is much the same regardless of their use or pumping capacity. First, the pump is positioned next to a nearby lake or stream, with its intake facing the body of water. A separate fuel tank is then connected to the pump, and an intake hose with a foot valve is attached to the intake. One or more lengths of hose are then connected to the pump's outlet, and the final length of hose is secured where the water is to be delivered; for fire-fighting, the hose is attached to a nozzle and hand held.

Before the intake hose is connected, it must be filled with water, i.e., "primed", as air pockets trapped inside the hose will cause the pump to lose suction and stop. The foot valve on the other end of the hose prevents water in the hose from draining back out, and also helps to keep damaging debris from getting in. After the intake hose is connected, the foot valve should be plunged

into the body of water several times to eliminate any air remaining in the intake hose. If prime is lost while the pump is running, you will have to repeat this last procedure.

Prior to starting the pump, position the valve just above the bottom of the lake or stream, where it will not pick up sand or muck, yet deep enough that wave and wind action will not expose it to air, causing the pump to lose its prime. Secure the valve in place with rocks or other objects as necessary, and start the pump.

Water pumps should be maintained and stored much like any other small engine powered device in this series.

Rules to Remember

Here are four rules to remember and follow when working on and operating machines powered by small engines.

- Use the four-point check to diagnose problems.
- Always play it safe. When in doubt, don't!
- Always prepare machines and engines properly for storage.
- Use your service and engine manuals, and follow the advice given.

Check Your Knowledge

1. Name three uses each for generators and water pumps.
2. What purpose does a foot valve serve on a water pump?
3. Why is it necessary to "prime" the pump?
4. As a final review, name the major differences between two- and four-stroke engines.