KOHLER® ENGINES

TECHNICIANS CERTIFICATION TEST

STUDY GUIDE

KOHLER ENGINES STUDY GUIDE
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ABOUT THIS STUDY GUIDE

Hello. My name is Professor du Lotz. I will be your navigator through this study guide, providing you with sample questions, important study hints and additional reference resources.

The guide has been developed to give you a clear understanding of the context and style of Kohler's Technician Certification Test. It is designed to be educational, meaningful, and even provide a smile or two.

Most of the information in this guide relates specifically to Kohler products and factory-suggested procedures. The guide does not cover basic four-stroke fundamentals in detail, but there are some in the first section to get you in the right frame of mind. It is assumed that candidates already have a thorough understanding of topics covered in EETC Certification Test.

This study guide is in a similar format to the actual test and has sample questions that may appear on the actual test. The actual test will be broken down into the following sections:

Engine Theory
Electrical Theory & Troubleshooting
Fuel Systems
Engine Measurements
Engine Analysis & Warranty
Service/Maintenance/Tool Usage

Although this guide does not cover all of these topics, it will prepare you for the types of questions that may be drawn from each of these areas for the actual test. To adequately understand these subjects, I highly recommend you review the following Kohler Co. booklets and manuals, which are included in this study guide.

Owners Manual Command 18-26 TP-2474-H
Service Manual Command 18-745 TP-2428-B
Measurement Guide TP-2159-B
Principles of Engine Operation TP-2209
Specs & Torques Book TP-2469
Engine Electrical Systems TP-2210-A
Carburetor Reference Book TP-2377-D
Warranty Policy & Procedure Book TP-2303-F
Failure Analysis Book TP-2298-B
Guide to Engine Rebuilding TP-2150-A

Parts Identification is not listed or part of the actual exam, but it is beneficial that you have knowledge of parts look-up procedures. It will help with nomenclature and identifying certain items, which may be Kohler specific.

The certification test contains one hundred and eighty questions, and you will have two and half hours to complete it. To help you prepare for the areas of the test that relate to Kohler products and procedures, this study sheet contains sample questions similar to those you can expect to encounter on the exam. An answer sheet is included at the back of the study guide (No peeking!). The guide also includes Kohler reference materials which you can use as study materials now, and on the job later. If you need to familiarize yourself with additional reference materials that are not included in this guide, those materials will be listed in the front of each section.

NOTE: The design and intent of the certification test is not to see how much you have memorized, but more importantly, that you can find the information needed. Therefore this test **allows** the use of service manuals and/or the study guide.

Our goal is to help you successfully complete the exam. If, after reviewing the guide, you have any questions about the test, contact the Kohler Technical Publications Department at (920) 453-5808 or (920) 457-4441 ext. 77172.

Good Luck!

About Certification

Kohler Expert Dealers are required to have one (1) certified technician (two would be preferred) on staff. To gain certification, candidates must pass the Kohler Technicians Certification test and be renewed every three years, in conjunction with attending annual Kohler Technician Update schools.

Benefits of Kohler Certification are both personal and professional. Certification helps ensure that technicians are able to provide the highest quality service and assistance to owners of Kohler-powered equipment. Certified Technicians are authorized to approve short block, miniblock, and engine replacements under warranty, at Expert Dealer locations.

Equally important, technicians gain prestige and credibility in the eyes of customers who appreciate doing business with factory-certified professionals. In particular, individuals who rely on Kohler-powered equipment to make their living or to keep their businesses operating are more likely to seek out Expert Dealers because of the higher caliber of service they can expect to receive from Certified Technicians. Similarly, equipment sales are often enhanced because customers are assured that Kohler Expert Dealers are better able to quickly take care of service problems both during and after the warranty period.

Certified Technicians are valuable Expert Dealer resources who provide:

- Courteous, knowledgeable responses to customer questions.
- Fast and accurate diagnosis of customer problems.
- Quick turnaround of customer equipment when it requires service.

Those who wear Kohler's official Certified Technician emblem on their uniforms are distinguished as having exceptional competence and high standards for meeting customer needs and expectations.

A WORD ABOUT GENUINE KOHLER PARTS

Reliability and high performance are major factors in attracting customers to Kohler Engines and convincing customers to insist on Kohler when they buy additional equipment or replacement engines. Kohler state-of-the-art engines are manufactured to precise specifications and exacting tolerances. They are subjected to countless balance, vibration, quality and parts compatibility tests to ensure exact component fit and reliable operation.

Randomly selected imitation replacement parts show extreme variations in quality and fit. The compromise made in the production of these imitations affect performance and engine life. The use of imitation parts can damage a customer's equipment and your reputation.

Kohler genuine parts have the same consistent quality that is built into every Kohler Engine. Technicians can educate customers about the time and resources that are spent in research, design and production of every part that goes into a Kohler engine. Customers should know that significant design and quality differences can exist between genuine parts and imitation replacements.

Over time, the performance and reliability of a Kohler engine is best protected by using parts manufactured to original equipment specifications.

SAMPLE QUESTIONS REFERENCE GUIDE

Subjects

OVERVIEW

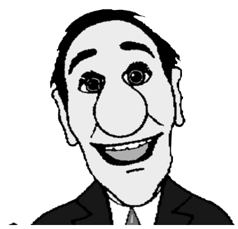
ENGINE THEORY AND FUNDAMENTALS

The questions in this section come from but are not limited to “Principles of Engine Operation” booklet TP-2209 and your general knowledge. If this does not get you thinking in the right way, you are in for a hard test!

ELECTRICAL THEORY & TROUBLESHOOTING

This section comes from, but is not limited to, “Engine Electrical Systems” TP-2210-A. We have also added test procedures from the various service manuals and service bulletins that for the most part, are Kohler specific. Additional books to study here would be any of our service manuals (i.e. TP-2428-B), bulletins (ESB-253), and updates, which include magneto, solid state, CD ignition, and SMART-SPARK™.

You should also be familiar with the service and test procedures for Kohler Co. charging and starting systems. We have combined theory and test procedures together in this section.



Hint:
Pay special attention to proper engine disassembly and assembly procedures shown in the service manuals.

FUEL SYSTEMS

This section of the test is made up from information supplied in “Principles of Operation,” service manuals, and service manual supplements which not only include basic Kohler carburetion but will also include EFI (Electronic Fuel Injection) and LP Fuel Systems.

ENGINE MEASUREMENTS

This section is made up from information supplied in our “Measurement Guide” (TP-2159-B), our ‘‘Specs & Torques” (TP-2469), and our “Guide to Engine Rebuilding” (TP-2150-A).

ENGINE ANALYSIS & WARRANTY

This section is made up from information supplied in our “Failure Analysis Book” (TP-2298-B) and “Policy & Procedure Book” (TP-2303-F). Your common engine knowledge and appropriate relationships with needed requirements should enable you to handle all questions.

SERVICE/MAINTENANCE/TOOL USAGE

This section is made up from the following: “Owners Manual” (TP-2474-H), “Command Service Manual” (TP-2428-B), “Specs & Torques” (TP-2469), and “Measurement Guide” (TP-2159-B).

Application & Crankshaft Guides

This section is made up from information supplied in the “Principles of Engine Operation” (TP-2209) as well as from charts supplied within the test book itself.

Sample Questions

Section 1: Engine Theory and Fundamentals

1. The volume inside a cylinder between BDC and TDC is called:
   A. bore.
   B. stroke.
   C. compression ratio.
   D. displacement.

2. Typical compression ratios for gasoline engines range from:
   A. 5.5:1 to 10.5:1
   B. 10.5:1 to 15.5:1
   C. 15:1 to 20:1
   D. 20:1 to 25:1

3. Viscosity of the crankcase oil should be based on:
   A. the air temperature at the time of operation.
   B. how much the engine will be used.
   C. the load that will be placed on the engine.
   D. engine horsepower.

4. When disassembling an engine, the parts must be cleaned thoroughly because:
   A. the customer will appreciate it.
   B. new paint won’t stick to the dirt and grease.
   C. they can then be accurately inspected and gauged.
   D. it reflects pride in your work.

Section 2: Electrical Theory & Troubleshooting

5. An ignition coil which has failed after 500 hours of operation has produced as many as _____ ignition sparks over its life.
   A. 50,000
   B. 500,000
   C. 5,000,000
   D. 50,000,000

6. Higher spark energy at low RPM's on Magnum engines is made possible in part due to:
   A. the position of the module inside the flywheel which increases the radius.
   B. a 1:46 primary/secondary ratio.
   C. a larger permanent magnet.
   D. more laminations in the iron core.

7. The spark plug in a magneto ignition will fire:
   A. when the breaker points open.
   B. when the breaker points close.
   C. at the moment the primary windings are "cut".
   D. at the moment the primary circuit closes.

8. The Magnum ignition module has a three-leg laminated iron core and:
   A. a coil with primary and secondary windings.
   B. a small "triggering coil".
   C. a coil with primary and secondary windings and a small "triggering" coil.
   D. a coil with primary and secondary windings, a small "triggering" coil, and eliminates the need for a flywheel magnet.

9. When measuring the secondary resistance of an ignition module with an ohmmeter, you find that the resistance is infinity ohms. What do you do next?
   A. Move on. The module is OK.
   B. Replace the module.
   C. Replace the "triggering" coil.
   D. Check for problems which could apply 12 volts to the kill terminal.

10. To test a 15/25 amp charging system, the voltmeter should be read:
   A. with the engine off.
   B. with the engine warmed up.
   C. with the engine running at 3600 RPM.
   D. with the engine running at 1000 RPM.

11. The electrical relay in an EFI system supplies power to the:
   A. fuel pump circuit.
   B. ignition coils.
   C. fuel injectors.
   D. all of the above.

12. You have a starter on a CH22 that will not energize. Choose the three most likely faults from the following list:
    1. battery
    2. transmission
    3. wiring
    4. brushes
    5. engine
    6. circuit breaker
    7. solenoid

    A. 5, 6, 7
    B. 1, 2, 3
    C. 3, 4, 5
    D. 1, 3, 7

13. The SAM needs a minimum of _______volts for proper operation.
    A. 7.25
    B. 6.75
    C. 9.00
    D. none of the above

Section 3: Fuel Systems

14. Maximum power in a gasoline engine is usually reached with an air-fuel ratio of about:
    A. 7:1
    B. 13:1
    C. 19:1
    D. 25:1

15. The dual fuel system:
    A. does not use an ECU.
    B. closely monitors the carbon monoxide levels in the exhaust.
    C. uses an oxygen sensor.
    D. none of the above.

16. The fuel in a CH18-25 LPG system is released from the supply tank in what form?
    A. Liquid
    B. Gas
    C. Combination of gas and liquid
    D. Varies depending on operating conditions

17. A clogged fuel injector problem on an EFI system may exhibit what symptom?
    A. Rough idle.
    B. Hesitation during acceleration.
    C. Fault codes related to fuel delivery.
    D. All of the above.

18 If a fuel injector in an EFI system is not operating:
    A. apply voltage to the fuel injector(s).
    B. connect a test light across the terminals in one injector connector and crank the engine over, watch for the test light to flash.
    C. ground the injector(s) to check if injector(s) will open/turn on.
    D. none of the above.

Section 4: Engine Measurements

19. To measure the diameter of a cylinder bore you need:
    A. an outside micrometer.
    B. an outside micrometer and a telescoping gauge.
    C. a feeler gauge.
    D. a wire gauge.

20. Maximum out-of-flatness for a cylinder head is:
    A. 0.001
    B. 0.002
    C. 0.003
    D. 0.004

21. Cylinder head flatness is measured with:
    A. a wire gauge.
    B. a feeler gauge.
    C. an inside micrometer.
    D. a telescoping gauge.

Section 5: Engine Analysis

22. A customer brings in their lawn tractor equipped with a CH18 engine and complains of oil consumption, smoking, and an engine knock. What would be your first step in diagnosing the problem?
    A. Recommend a rebuild.
    B. Remove the cylinder heads for inspection.
    C. Perform a preliminary examination.
    D. Start a tear down analysis.

23. An L-head engine has heavy ring wear with little or no bore wear. What conditions might have caused this?
    A. Lack of oil.
    B. Contaminants in the cylinder.
    C. High operating temperatures.
    D. Fuel dilution in crankcase oil.

24. A piston with black, scorched deposits on the skirt could indicate:
    A. insufficient running clearances.
    B. the piston was defective.
    C. loss of oil pressure.
    D. high combustion temperatures and restricted cooling.

25. Choose the response that contains only the item or items from the list below that are covered under Kohler's warranty.
    1. Normal wear.
    2. Routine tune-up or adjustment.
    3. Damage due to improper handling or accident.
    4. Damage caused by a defective part.
    5. Damage due to improper or insufficient lubrication.
    6. Damage caused by faulty workmanship in manufacture.

    A. 5
    B. 2, 5
    C. 3, 6
    D. 4, 6

26. A customer is willing to wait for a warranty decision prior to having the services performed. You should:
    A. complete a Warranty Claim and Engine Inspection Data Record and have your Central Distributor representative review the failed parts and forms.
    B. complete a Warranty Claim form, sign box 12 or 17, perform the repair, and send the form to Kohler Co.
    C. inform the customer that, as a matter of procedure, the repair has to be made first in order to settle any areas of dispute.
    D. contact the Central Distributor to set up an "on site" inspection of the damaged parts.

SECTION 6: SERVICE/MAINTENANCE/TOOL USAGE

27. On a CH25, the oil filter should be changed:
    A. with every oil change.
    B. when it starts to leak.
    C. when the Oil Sentry™ light comes on.
    D. every 200 hours.

28. You inspect a CV18 for a breather problem. The crankcase vacuum reading shows pressure. Where would you find the breather reed(s)?
    A. In between #1 and #2 cylinder, under the breather cover.
    B. On the #1 and #2 cylinder between the hydraulic lifter bores.
    C. In the breather canister, located on the #1 valve cover.
    D. In the breather canister, located on the #2 valve cover.

29. Testing an Oil Sentry™ pressure switch requires a pressure regulator, pressure gauge, continuity tester and:
    A. an ammeter.
    B. a vacuum gauge.
    C. an oil sump thermocouple.
    D. compressed air.

30. While performing a leakdown test, the gauge reads in the “low” zone. How do you interpret this?
    A. A defective exhaust valve.
    B. Piston rings and cylinder are in good condition.
    C. Some wear on the cylinder walls but the engine is still useable.
    D. Engine should be reconditioned or replaced.

31. You are testing for spark using a Kohler ignition tester on a CH20 and find neither side firing. What is your next step?
    A. Recheck the position of the ignition switch and check for a shorted kill lead.
    B. Check the battery voltage to the SAM.
    C. Check the red, green, and white lead from the SAM.
    D. Connect the ignition tester to the yellow lead at one of the ignition modules, crank the engine and observe the LED.

SECTION 7: APPLICATION & CRANKSHAFT GUIDES

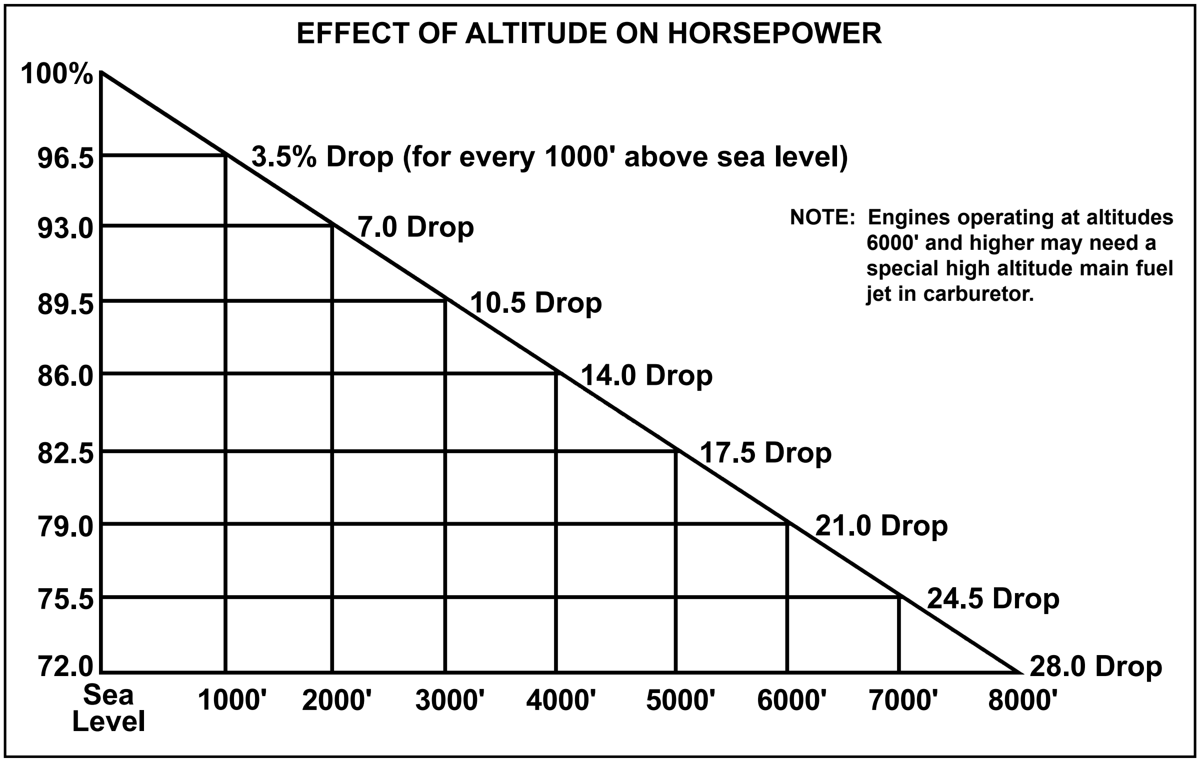


Chart: Altitude Effect on HP.

Figure 1.

32. In Figure 1, what percentage of horsepower is available to an engine operating at 4000 ft. above sea level?
    A. 82.5%
    B. 86%
    C. 89.5%
    D. 93%

TRANSMISSION EFFICIENCIES CHART

Transmission	Efficiency (Typical)
Direct Coupled	100%
V-belt	96-98%
Roller Chains	95-97%
Spur Gears	96%
Gear Reductions	(Contact Manufacturer)
Pumps	50-80%

Figure 2.

33. Using Figure 2 as a guide, what percentage of power is lost using a belt and pulley type drive system?
    A. None
    B. 2-4%
    C. 3-5%
    D. 20-50%

34. A customer has designed a new machine and needs an engine. They estimate the power requirement will be 4 HP at 3600 RPM. The transmission will be a friction drive system (spur gears). It will be operated at an altitude of 2000 feet. Use Figures 1 and 2 to determine what percentage of horsepower loss should be figured in when choosing the right engine for this application?
    A. 3%
    B. 7%
    C. 11%
    D. 15%

Answer Sheet

1. D
2. A
3. A
4. C
5. D
6. B
7. A
8. C
9. B
10. C
11. D
12. D
13. A
14. B
15. D
16. B
17. D
18. B
19. B
20. C
21. B
22. C
23. C
24. D
25. D
26. A
27. D
28. B
29. D
30. B
31. A
32. B
33. B
34. C

Equipment & Engine Training Council

WE SUPPORT EETC

TECHNICIAN CERTIFICATION

LITHO IN U.S.A.

Revised 9/04

OWNER'S MANUAL

COMMAND SERIES
CH18-26, CH730-745
HORIZONTAL CRANKSHAFT

KOHLER® ENGINES

Safety Precautions

To ensure safe operations please read the following statements and understand their meaning. Also refer to your equipment owner's manual for other important safety information. This manual contains safety precautions which are explained below. Please read carefully.

WARNING
Warning is used to indicate the presence of a hazard that *can* cause *severe* personal injury, death, or substantial property damage if the warning is ignored.

CAUTION
Caution is used to indicate the presence of a hazard that *will* or *can* cause *minor* personal injury or property damage if the caution is ignored.

NOTE
Note is used to notify people of installation, operation, or maintenance information that is important but not hazard-related.

For Your Safety!
These precautions should be followed at all times. Failure to follow these precautions could result in injury to yourself and others.

WARNING

Explosive Fuel can cause fires and severe burns.

Stop engine before filling fuel tank.

Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

WARNING

Rotating Parts can cause severe injury.

Stay away while engine is in operation.

Rotating Parts!
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Electrical Shock!
Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

WARNING

Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

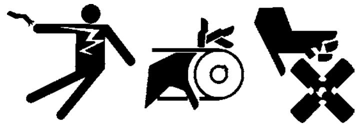
Hot Parts!
Engine components can get extremely hot from operation. To prevent severe burns, do not touch these areas while the engine is running, or immediately after it is turned off. Never operate the engine with heat shields or guards removed.

California Proposition 65 Warning

Engine exhaust from this product contains chemicals known to the State of California to cause cancer, birth defects, or other reproductive harm.

Safety Precautions (Cont.)

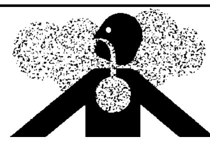
⚠ WARNING



Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug leads before servicing.

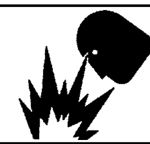
⚠ WARNING



Carbon Monoxide can cause severe nausea, fainting or death.

Do not operate engine in closed or confined area.

⚠ WARNING



Explosive Gas can cause fires and severe acid burns.

Charge battery only in a well ventilated area. Keep sources of ignition away.

Accidental Starts!
Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Lethal Exhaust Gases!
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled. Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

Explosive Gas!
Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

Congratulations – You have selected a fine four-cycle, twin cylinder, air-cooled engine. Kohler designs long life strength and on-the-job durability into each engine...making a Kohler engine dependable...dependability you can count on. Here are some reasons why:

- Efficient overhead valve design and full pressure lubrication provide maximum power, torque, and reliability under all operating conditions.
- Dependable, maintenance-free electronic ignition ensures fast, easy starts time after time.
- Kohler engines are easy to service. All routine service areas like the dipstick, oil fill, air cleaner, and spark plugs are easily and quickly accessible.
- Parts subject to the most wear and tear (like the cylinder liner* and camshaft) are made from precision formulated cast iron. Because the cylinder liner* can be rebored, these engines can last even longer.

  *Some CH25/26 engines have POWER-BORE™ Cylinders. These cylinders are plated with nickel-silicon to give increased power, virtually permanent cylinder life, superior oil control, and reduced exhaust emissions. These cylinders cannot be rebored.

- Every Kohler engine is backed by a worldwide network of over 10,000 distributors and dealers. Service support is just a phone call away. Call 1-800-544-2444 (U.S. & Canada) for Sales & Service assistance.

To keep your engine in top operating condition, follow the maintenance procedures in this manual.

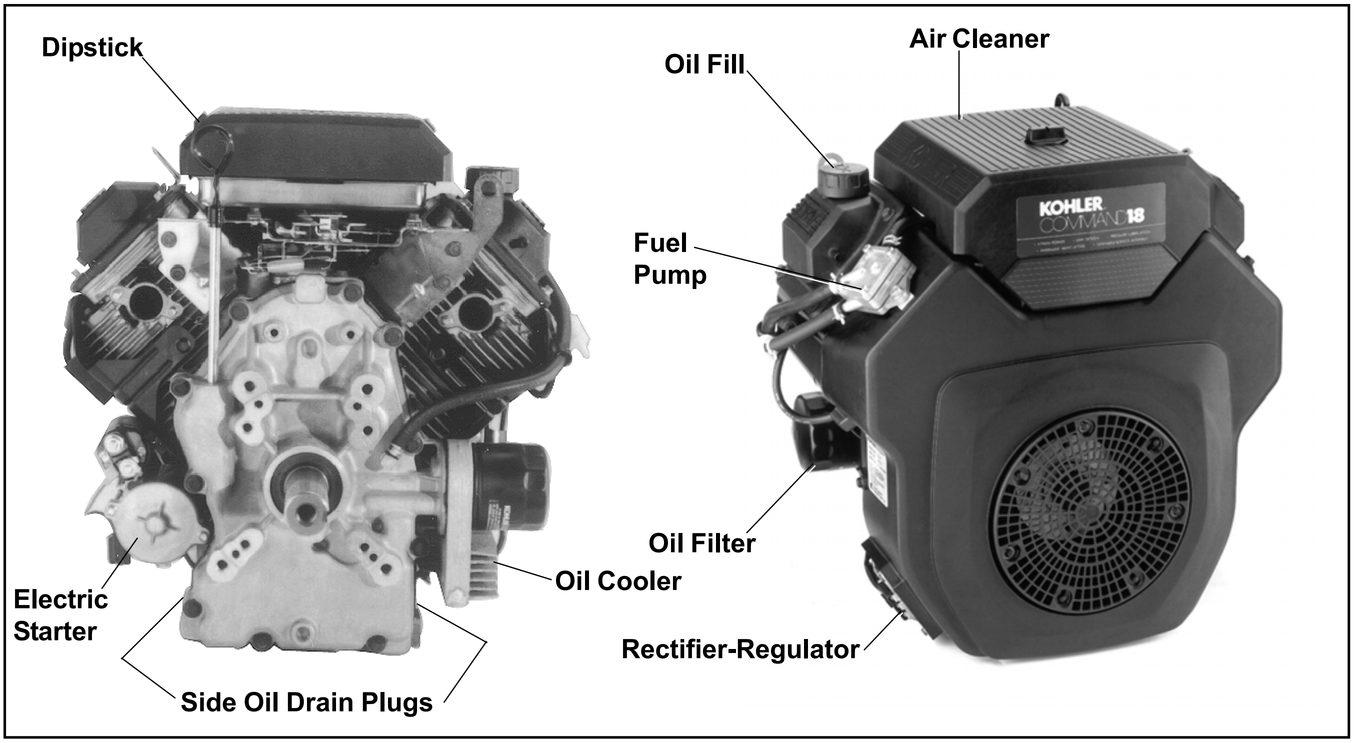


Figure 1. Typical Command Horizontal Shaft Carbureted Engine.

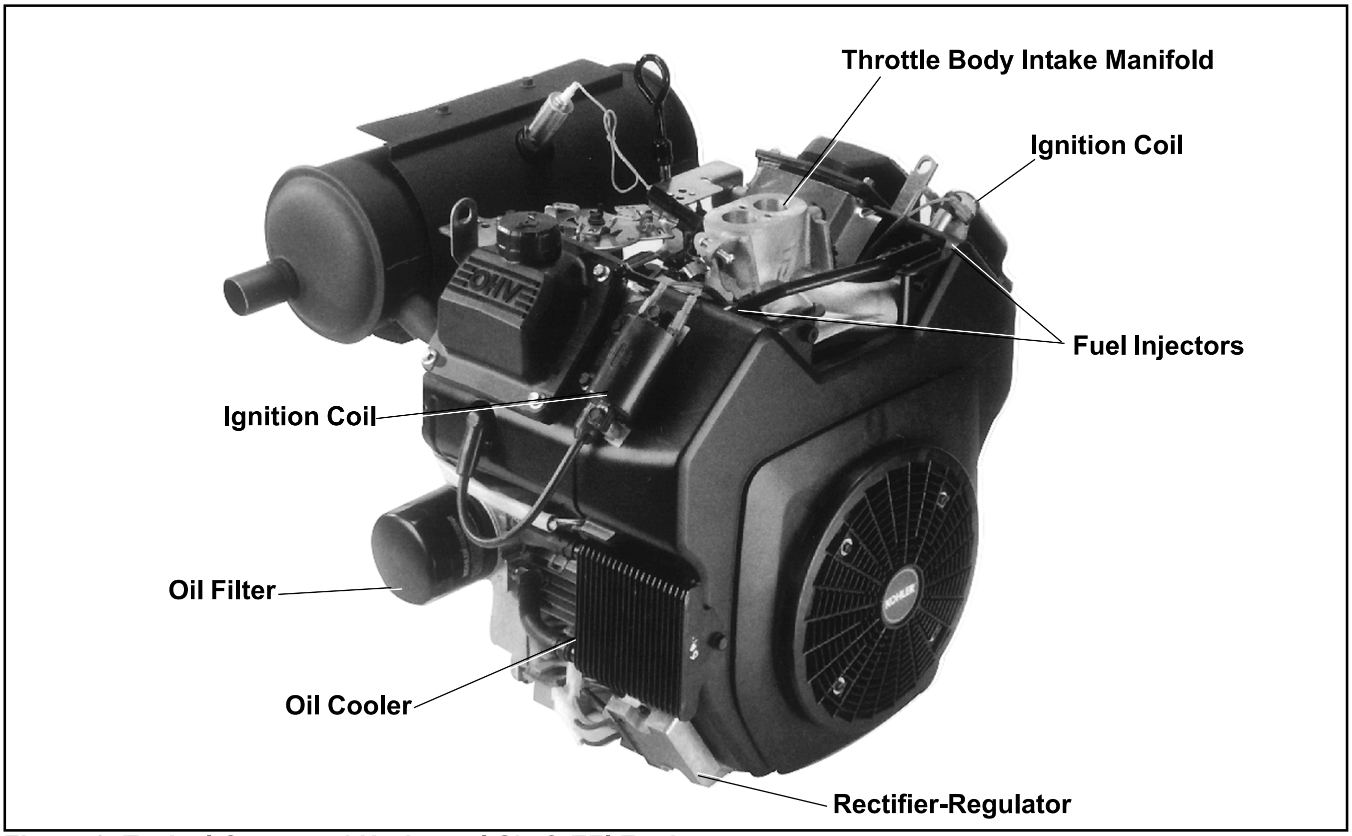


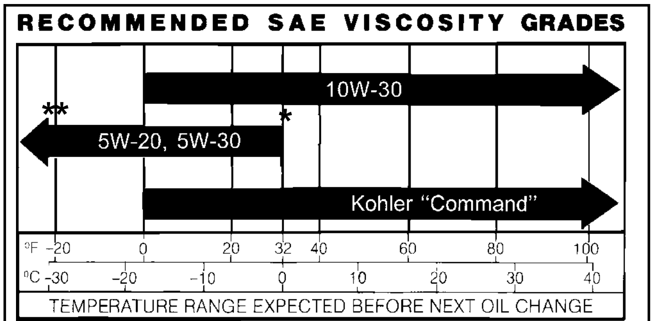
Figure 2. Typical Command Horizontal Shaft EFI Engine.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important. So is checking oil daily and changing oil regularly. Failure to use the correct oil, or using dirty oil, causes premature engine wear and failure.

Oil Type

Use high quality detergent oil of **API (American Petroleum Institute) service class SG, SH, SJ or higher**. Select the viscosity based on the air temperature at the time of operation as shown in the following table.



*Use of synthetic oil having 5W-20 or 5W-30 rating is acceptable, up to 4°C (40°F).
**Synthetic oils will provide better starting in extreme cold below 23°C (-10°F).

Figure 3. Viscosity Grades Table.

NOTE: Using other than service class SG, SH, SJ or higher oil or extending oil change intervals longer than recommended can cause engine damage.

NOTE: Synthetic oils meeting the listed classifications may be used with oil changes performed at the recommended intervals. However to allow piston rings to properly seat, a new or rebuilt engine should be operated for at least 50 hours using standard petroleum based oil before switching to synthetic oil.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 4.

Figure 4. Oil Container Logo.

Refer to "Maintenance Instructions" beginning on page 8 for detailed oil check, oil change, and oil filter change procedures.

Fuel Recommendations

⚠ **WARNING: Explosive Fuel!**

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

Do not use gasoline left over from the previous season, to minimize gum deposits in fuel system and to ensure easy starting.

Do not add oil to the gasoline.

Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results use only clean, fresh, **unleaded** gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Unleaded gasoline is recommended as it leaves less combustion chamber deposits and reduces harmful exhaust emissions. Leaded gasoline is not recommended and **must not** be used on EFI engines, or on other models where exhaust emissions are regulated.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Engine Identification Numbers

When ordering parts, or in any communication involving an engine, always give the **Model, Specification, and Serial Numbers** of the engine.

The engine identification numbers appear on a decal affixed to the engine shrouding. Include letter suffixes, if there are any.

Record your engine identification numbers on the identification label below (Figure 5) for future reference.

KOHLER

IMPORTANT ENGINE INFORMATION
THIS ENGINE MEETS U.S. EPA AND CA 2005 AND LATER AND EC STAGE II (SN:4) EMISSION REGS FOR SI SMALL OFF–ROAD ENGINES

FAMILY
TYPE APP
DISPL. (CC)
MODEL NO. N11236
SPEC. NO.
SERIAL NO.
BUILD DATE
OEM PROD. NO.

EMISSION COMPLIANCE PERIOD:
EPA: CARB:
CERTIFIED ON:
REFER TO OWNER'S MANUAL FOR HP RATING, SAFETY, MAINTENANCE AND ADJUSTMENTS
1-800-544-2444 www.kohlerengines.com
KOHLER CO. KOHLER, WISCONSIN USA

Figure 5. Engine Identification Label.

The Emission Compliance Period referred to on the Emission Control or Air Index label indicates the number of operating hours for which the engine has been shown to meet Federal and CARB emission requirements. The following table provides the Engine Compliance Period (in hours) associated with the category descriptor found on the certification label.

Emission Compliance Period (Hours)

EPA	Category C 250 hours	Category B 500 hours	Category A 1000 hours
CARB	Moderate 125 hours	Intermediate 250 hours	Extended 500 hours

Refer to certification label for engine displacement.

Exhaust Emission Control System for models CH18,20,22,23,25,730,740 is EM. Exhaust Emission Control System for models CH26 and CH745 are EM, O2S, ECM, MFI.

Model Designation

Model CH20S for example: C designates Command engine, H designates horizontal crankshaft, and 20 designates horsepower. Some model numbers (CH730) use a numerical designation rather than horsepower. A letter suffix designates a specific version as follows:

Suffix	Designates
S	Electric Start
ST	Electric Start/Retractable Start
QS	Quiet Model/Electric Start
EP	Electric Plant
CS	Clutch Model/Electric Start

Operating Instructions

Also read the operating instructions of the equipment this engine powers.

Pre-Start Checklist

- Check oil level. Add oil if low. Do not overfill.
- Check fuel level. Add fuel if low.
- Check cooling air intake areas and external surfaces of engine. Make sure they are clean and unobstructed.
- Check that the air cleaner components and all shrouds, equipment covers, and guards are in place and securely fastened.
- Check that any clutches or transmissions are disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. The shift lever must be exactly in neutral to prevent resistance which could keep the engine from starting.

WARNING: Lethal Exhaust Gases!
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled. Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

Cold Weather Starting Hints

1. Be sure to use the proper oil for the temperature expected. See Figure 3 on page 5.
2. Disengage all possible external loads.
3. Be sure the battery is in good condition. A warm battery has much more starting capacity than a cold battery.
4. Use fresh winter grade fuel. NOTE: Winter grade gasoline has higher volatility to improve starting. Do not use gasoline left over from summer.

Starting

1. Place the throttle control **midway** between the **"slow"** and **"fast"** positions. Place the choke control (non-EFI engines only) into the **"on"** position. See Figure 6.

Figure 6. Optional Engine Mounted Throttle and Choke Controls (CH18-25,CH730,740).

2. Start the engine by activating the key switch. Release the switch as soon as the engine starts.

   EFI Engines Only – Initial Starting or After Running out of Fuel (Dry System)

   a. Turn the key switch to the **"on"** position for one minute. Allow the fuel pump to cycle and prime the system. Turn the key switch **"off"**.

   b. Turn the key switch to the **"start"** position, crank and start engine.

   c. If the engine fails to start, repeat steps "a" and "b". If the engine does not start after two priming intervals, contact your Kohler Engine Service Dealer for further assistance.

   NOTE: Do not crank the engine continuously for more than 10 seconds at a time. If the engine does not start, allow a 60 second cool down period between starting attempts. Failure to follow these guidelines can burn out, or permanently damage, the starter motor.

   NOTE: Upon start-up, a metallic ticking may occur. This is caused by hydraulic lifter leakdown during storage. Run the engine for 5 minutes. The noise will normally cease in the first minute. If noise continues, run the engine at mid-throttle for 20 minutes. If noise persists, take the engine to your local authorized Kohler Engine Service Dealer.

   NOTE: If the engine develops sufficient speed to disengage the starter but does not keep running (a false start), engine rotation must be allowed to come to a complete stop before attempting to restart the engine. If the starter is engaged while the flywheel is rotating, the starter pinion and flywheel ring gear may clash resulting in damage to the starter.

   If the starter does not turn the engine over, shut off starter immediately. Do not make further attempts to start the engine until the condition is corrected. Do not jump start using another battery (refer to "Battery" on this page). See your Kohler Engine Service Dealer for service assistance.

Carbureted Engines Only:

3. **For a Cold Engine –** Gradually return the choke control to the **"off"** position after the engine starts and warms up.

   The engine/equipment may be operated during the warm-up period, but it may be necessary to leave the choke partially on until the engine warms up.

4. **For a Warm Engine –** Return choke to **"off"** position as soon as engine starts.

Stopping

1. Remove the load by disengaging all PTO driven attachments.

2. **For Carbureted Engines Without A Shutdown Solenoid:** Move the throttle to the **"slow"** or **"low"** idle position. Allow the engine to run at idle for 30-60 seconds; then stop the engine.

   For Carbureted Engines Equipped With A Shutdown Solenoid: Position the throttle control somewhere between half and full throttle; then stop the engine.

   For EFI Engines: Move the throttle to the "slow" or "idle" position; turn key **"off"** to stop engine.

Battery

A 12 volt battery is normally used. Refer to the operating instructions of the equipment this engine powers for specific battery requirements.

If the battery charge is not sufficient to crank the engine, recharge the battery (see page 13).

Operating

Angle of Operation

This engine will operate continuously at angles up to 25°. Check oil level to assure crankcase oil level is at the "F" mark on the dipstick.

Refer to the operating instructions of the equipment this engine powers. Because of equipment design or application, there may be more stringent restrictions regarding the angle of operation.

NOTE: Do not operate this engine continuously at angles exceeding 25° in any direction. Engine damage could result from insufficient lubrication.

Cooling

NOTE: If debris builds up on the grass screen or other cooling air intake areas, stop the engine immediately and clean. Operating the engine with blocked or dirty air intake and cooling areas can cause extensive damage due to overheating.

WARNING: Hot Parts!

Engine components can get extremely hot from operation. To prevent severe burns, do not touch these areas while the engine is running, or immediately after it is turned off. Never operate the engine with heat shields or guards removed.

Engine Speed

NOTE: Do not tamper with the governor setting to increase the maximum engine speed. Overspeed is hazardous and will void the engine warranty. The maximum allowable high idle speed for these engines is 3750 RPM, no load.

Maintenance Instructions

Maintenance, repair, or replacement of the emission control devices and systems, which are being done at the customers expense, may be performed by any non-road engine repair establishment or individual. Warranty repairs must be performed by an authorized Kohler service outlet.

WARNING: Accidental Starts!

Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Maintenance Schedule

These required maintenance procedures should be performed at the frequency stated in the table. They should also be included as part of any seasonal tune-up.

Frequency	Maintenance Required
Daily or Before Starting Engine	• Fill fuel tank. • Check oil level. • Check air cleaner for dirty[1], loose, or damaged parts. • Check air intake and cooling areas, clean as necessary[1].
Every 25 Hours	• Service precleaner element[1].
Every 100 Hours	• Replace air cleaner element[1]. • Change oil. (More frequently under severe conditions.) • Remove cooling shrouds and clean cooling areas[1,3]. • Check oil cooler fins, clean as necessary (if equipped).
Every 200 Hours	• Check spark plug condition and gap. • Change oil filter. • Replace fuel filter (carbureted engines).
Every 250 Hours	• Replace heavy-duty air cleaner element and check inner element[1].
Annually or Every 500 Hours	• Have bendix starter drive serviced[2]. • Have solenoid shift starter disassembled and cleaned[2].
Every 500 Hours	• Have crankshaft spline lubricated[2].
Every 1500 Hours	• Replace fuel filter[1] (EFI engines).

[1]Perform these maintenance procedures more frequently under extremely dusty, dirty conditions.

[2]Only required for Denso starters. Not necessary on Delco starters. Have a Kohler Engine Service Dealer perform this service.

[3]Cleanout Kits 25 755 20-S (black) or 25 755 21-S (gold) allow cooling areas to be cleaned without removing shrouds.

Check Oil Level

The importance of checking and maintaining the proper oil level in the crankcase cannot be overemphasized. Check oil **BEFORE EACH USE** as follows:

1. Make sure the engine is stopped, level, and is cool so the oil has had time to drain into the sump.
2. To keep dirt, debris, etc., out of the engine, clean the area around the dipstick before removing it.
3. Remove the dipstick; wipe oil off. Reinsert the dipstick into the tube and press all the way down.
4. Remove the dipstick and check the oil level.

   The oil level should be up to, but not over, the "F" mark on the dipstick. See Figure 7.

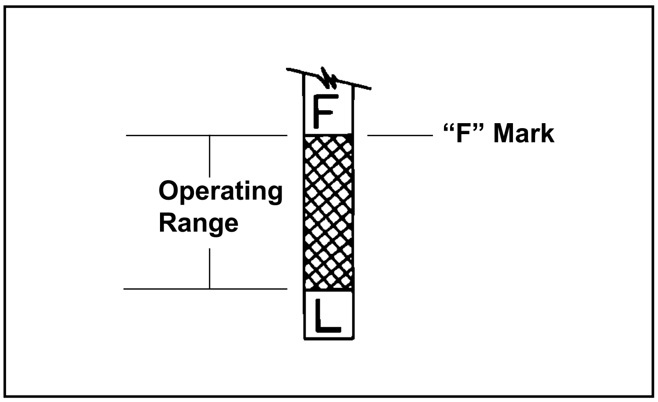


Figure 7. Oil Level Dipstick.

5. If the level is low, add oil of the proper type, up to the "F" mark on the dipstick. (Refer to "Oil Type" on page 5.) Always check the level with the dipstick before adding more oil.

   NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the "L" mark or over the "F" mark on the dipstick.

Oil Sentry™

Some engines are equipped with an optional Oil Sentry™ oil pressure switch. If the oil pressure decreases below an acceptable level, the Oil Sentry™ will either shut off the engine or activate a warning signal, depending on the application.

NOTE: Make sure the oil level is checked **BEFORE EACH USE** and is maintained up to the "F" mark on the dipstick. This includes engines equipped with Oil Sentry™.

Change Oil and Filter, Service Oil Cooler

Change Oil

Change oil after every **100 hours** of operation (more frequently under severe conditions). Refill with service class SG, SH, SJ or higher oil as specified in the "Viscosity Grades" table (Figure 3) on page 5.

Change the oil while the engine is still warm. The oil will flow more freely and carry away more impurities. Make sure the engine is level when filling, checking, and changing the oil.

Change the oil as follows (see Figures 8 and 9):

1. To keep dirt, debris, etc., out of the engine, clean the area around the oil fill cap/dipstick before removing it.
2. Remove one of the oil drain plugs, oil fill cap, and dipstick. Be sure to allow ample time for complete drainage.
3. Reinstall the drain plug. Make sure it is tightened to **13.6 N·m (10 ft. lb.)** torque.
4. Fill the crankcase, with new oil of the proper type, to the "F" mark on the dipstick. Refer to "Oil Type" on page 5. Always check the level with the dipstick before adding more oil.
5. Reinstall the oil fill cap and tighten securely. Reinstall dipstick.

   NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the "L" mark or over the "F" mark on the dipstick.

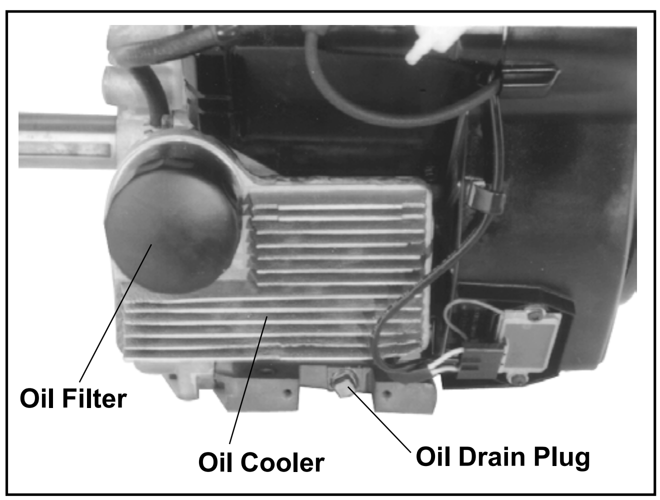


Figure 8. Oil Drain Plugs, Oil Filter, and Oil Cooler (CH25 shown).

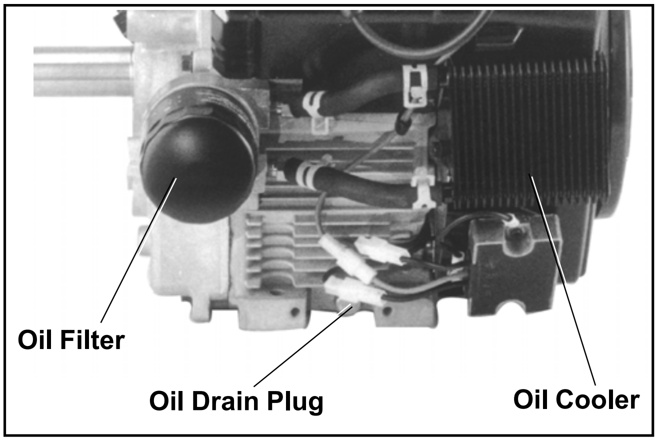


Figure 9. Oil Drain Plugs, Oil Filter, and Oil Cooler (CH26 shown).

Change Oil Filter

Replace the oil filter **at least every other oil change (every 200 hours of operation)**. *Always use a genuine Kohler oil filter, Part No. 12 050 01-S.*

Replace the oil filter as follows:

1. Drain the oil from the engine crankcase.

2. Allow the oil filter to drain.

3. Before removing the oil filter, clean the area around the oil filter to keep dirt and debris out of the engine. Remove the old filter. Wipe off the surface where the oil filter mounts.

4. Place a new replacement filter in a shallow pan with the open end up. Pour new oil, of the proper type, in through the threaded center hole. Stop pouring when the oil reaches the bottom of the threads. Allow a minute or two for the oil to be absorbed by the filter material.

5. Apply a thin film of clean oil to the rubber gasket on the new filter.

6. Install the replacement oil filter to the filter adapter or oil cooler. Turn the oil filter clockwise until the rubber gasket contacts the filter adapter or oil cooler, then tighten the filter an additional **2/3 to 1 turn**.

7. Reinstall the drain plug. Make sure it is tightened to **13.6 N·m (10 ft. lb.)** torque.

8. Fill the crankcase with new oil of the proper type to the “F” mark on the dipstick.

9. Start the engine and check for oil leaks. Correct any leaks before placing the engine into service. Check oil level to be sure it is up to but not over the “F” mark.

Service Oil Cooler

Some engines are equipped with an oil cooler. One style of oil cooler mounts on the engine crankcase and has the oil filter on it (See Figure 8). The other style of oil cooler is mounted on the blower housing (See Figure 9), separate from the oil filter.

Inspect and clean the oil cooler **every 100 hours of operation** (more frequently under severe conditions). Oil cooler must be kept free of debris.

To service the crankcase mounted oil cooler clean off the outside fins with a brush or with compressed air.

To service the blower housing mounted oil cooler, clean the outside of fins with a brush. Remove the two screws holding the cooler unit to the blower housing. Tilt the cooler downward as shown in Figure 10. Clean the inside of cooler with a brush as shown in Figure 10 or with compressed air. After cleaning, reinstall oil cooler to blower housing with two mounting screws.

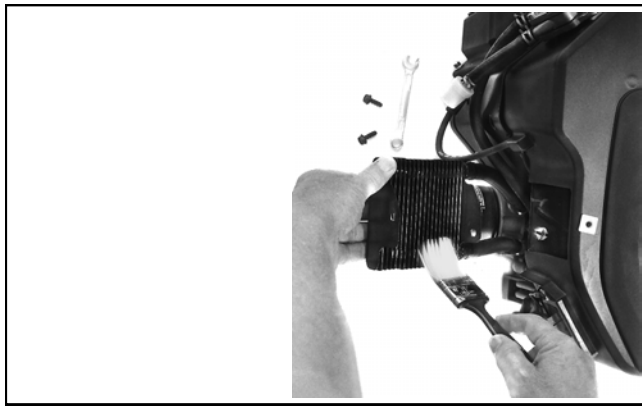


Figure 10.

Service Precleaner and Air Cleaner Element

This engine is equipped with a replaceable, high density paper air cleaner element. Most engines are also equipped with an oiled, foam precleaner which surrounds the paper element. See Figure 11.

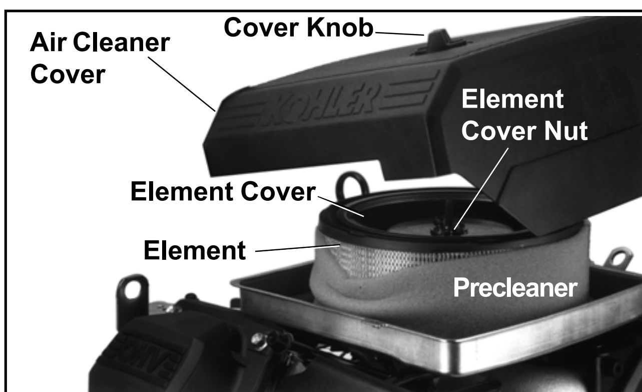


Figure 11. Air Cleaner System Components.

Check the air cleaner **daily or before starting the engine**. Check for a buildup of dirt and debris around the air cleaner system. Keep this area clean. Also check for loose or damaged components. Replace all bent or damaged air cleaner components.

NOTE: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine causing premature wear and failure.

Service Precleaner
If so equipped, wash and reoil the precleaner every **25 hours** of operation (more often under extremely dusty or dirty conditions).

1. Loosen the cover retaining knob and remove the cover.
2. Remove the precleaner from the paper element.
3. Wash the precleaner in warm water with detergent. Rinse the precleaner thoroughly until all traces of detergent are eliminated. Squeeze out excess water (do not wring). Allow the precleaner to air dry.
4. Saturate the precleaner with new engine oil. Squeeze out all excess oil.
5. Reinstall the precleaner over the paper element.
6. Reinstall the air cleaner cover. Secure cover with the cover retaining knob.
7. When precleaner replacement is necessary, order genuine Kohler parts.

24 083 02-S	61 mm (2.40 in.) high x 173 mm (6.81 in.) O.D.
24 083 05-S	71 mm (2.79 in.) high x 173 mm (6.81 in.) O.D.

Service Paper Element
Every **100 hours** of operation (more often under extremely dusty or dirty conditions) replace the paper element.

1. Loosen the cover retaining knob and remove the cover.
2. Remove the element cover nut, element cover, and paper element with precleaner.
3. Remove the precleaner (if so equipped) from the paper element. Service the precleaner as described above.
4. Do not wash the paper element or **use pressurized air**, as this will damage the element. Replace a dirty, bent, or damaged element with a genuine Kohler element. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged.
5. When servicing the air cleaner, check the air cleaner base. Make sure it is secured and not bent or damaged. Also, check the element cover for damage or improper fit. Replace all damaged air cleaner components.

   NOTE: If any loose dirt or debris fell on the air cleaner base when the element was removed, carefully remove it and wipe the base clean. Be careful that none of it drops into the intake throat. Check the condition of the rubber seal on the air cleaner stud. If the condition is questionable in any way, replace it with the new seal packaged with the replacement element.

6. Reinstall the paper element, precleaner, element cover, element cover nut, and air cleaner cover. Secure cover with the cover retaining knob.
7. When element replacement is necessary, order genuine Kohler parts.

47 083 03-S	65 mm (2.55 in.) high x 178 mm (7.00 in.) O.D.
24 083 03-S	74 mm (2.91 in.) high x 178 mm (7.00 in.) O.D.

Heavy-Duty Air Cleaner

To Service
Every **250 hours** of operation (more often under extremely dusty or dirty conditions), replace the paper element and check inner element. Follow these steps.

1. Unhook the two retaining clips and remove the end cap from the air cleaner housing.
2. Pull the air cleaner element out of the housing. See Figure 12.

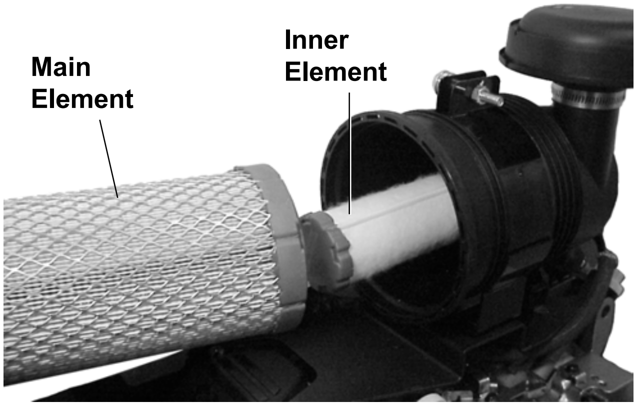


Figure 12. Removing Elements.

3. After the main element is removed, check the condition of the inner element. It should be replaced whenever it appears dirty, typically every other time the main element is replaced. Clean the area around the base of the inner element before removing it, so dirt does not get into the engine.

4. **Do not** wash the paper element and inner element or use pressurized air, this will damage the elements. Replace dirty, bent or damaged elements with new genuine Kohler elements as required. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged.

5. Check all parts for wear, cracks, or damage. Replace any damaged components.

6. Install the new inner element, Kohler Part No. **25 083 04-S** followed by the outer element, Kohler Part No. **25 083 01-S**. Slide each fully into place in the air cleaner housing.

7. Reinstall the end cap so the dust ejector valve is down and secure with the two retaining clips. See Figure 13.

Figure 13. Heavy-Duty Air Cleaner Assembly.

Clean Air Intake/Cooling Areas
To ensure proper cooling, make sure the grass screen, cooling fins, and other external surfaces of the engine are kept clean **at all times**.

Every **100 hours** of operation (more often under extremely dusty, dirty conditions), remove the blower housing* and other cooling shrouds. Clean the cooling fins and external surfaces as necessary. Make sure the cooling shrouds are reinstalled.

NOTE: Operating the engine with a blocked grass screen, dirty or plugged cooling fins, and/or cooling shrouds removed, will cause engine damage due to overheating.

*Cleanout kits 25 755 20-S (black) or 25 755 21-S (gold) allow inspection and cleanout of the cooling fins, without removing the blower housing.

Ignition System

Carbureted Engines - Use an electronic Capacitive Discharge (CD) ignition system. Other than periodically checking/replacing the spark plugs, no maintenance, timing, or adjustments are necessary or possible with this system.

EFI Engines - Incorporate a computer-controlled battery ignition system with individual coils. Other than periodically checking/replacing the spark plugs, no maintenance, timing, or adjustments are necessary or possible with this system.

Check Spark Plugs
Every **200 hours** of operation, remove the spark plugs, check condition, and reset the gap or replace with new plugs as necessary. The standard spark plug is a Champion® RC12YC (Kohler Part No. 12 132 02-S). A high-performance spark plug, Champion® Platinum 3071 (used on Pro Series engines, Kohler Part No. 25 132 12-S) is also available. Equivalent alternate brand plugs can also be used.

1. Before removing the spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine.

2. Remove the plug and check its condition. Replace the plug if worn or reuse is questionable.

   NOTE: Do not clean the spark plug in a machine using abrasive grit. Some grit could remain in the spark plug and enter the engine causing extensive wear and damage.

3. Check the gap using a wire feeler gauge. Adjust the gap to **0.76 mm (0.030 in.)** by carefully bending the ground electrode. See Figure 14.

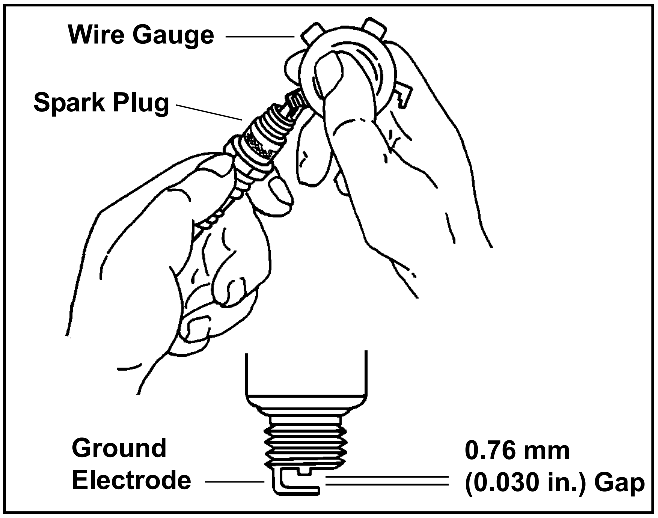


Figure 14. Servicing Spark Plug.

4. Reinstall the spark plug into the cylinder head. Torque the spark plug to **24.4-29.8 N·m (18-22 ft. lb.)**.

Battery Charging

WARNING: Explosive Gas!
Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

NOTE: Do not apply 12 volt DC to kill terminal of ignition module.

Fuel System

WARNING: Fuel System Under Pressure!
The EFI fuel system operates under high pressure, and the fuel filter and fuel line used must be approved system components only. Use of substitute parts can result in system failure, gasoline leakage and possible explosion.

Fuel Filter

Carbureted Engines: Most engines are equipped with an in-line fuel filter. Periodically inspect the filter and replace with a genuine Kohler filter every **200 operating hours**.

EFI Engines: A special, high volume, high pressure filter with greater filtration capabilities and internal surface area is used. See Figure 15.

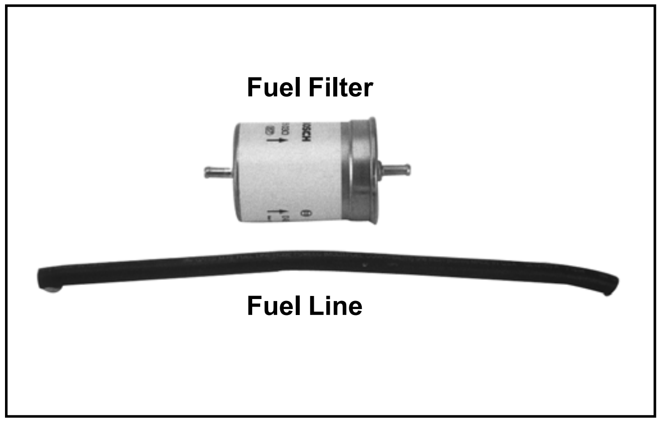


Figure 15. EFI Fuel Filter and Line.

Replacement is recommended **every 1500 hours**, or more frequently under extremely dusty or dirty conditions. When replacement is necessary, always use genuine Kohler parts.

Fuel Line

EFI Engines: A special fuel line, capable of withstanding the high pressure of the EFI fuel system, is used (must meet SAE R9 specifications). See Figure 15. If fuel line must be replaced, see your Kohler Engine Service Dealer.

Carburetor Troubleshooting and Adjustments

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

The carburetor is designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. To comply with current emission regulations, the fuel mixture settings are made at the factory and cannot be adjusted.

NOTE: To ensure correct engine operation at altitudes above 1525 meters (5000 ft.), it may be necessary to have an authorized Kohler dealer install a special high-altitude jet kit in the carburetor. If a high-altitude kit has been installed, the engine must be reconverted to the original jet size, before it is operated at lower altitudes, or overheating and engine damage can result.

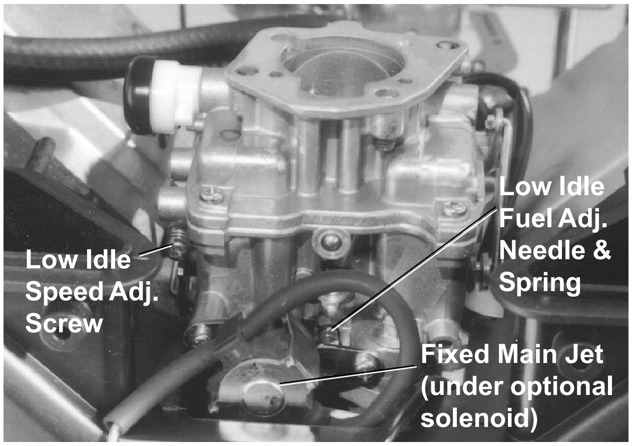


Figure 16. Carburetor (CH18-25,CH730,740).

Troubleshooting

If engine troubles are experienced that appear to be fuel system related, check the following areas before adjusting the carburetor.

- Make sure the fuel tank is filled with clean, fresh gasoline.
- Make sure the fuel tank cap vent is not blocked and that it is operating properly.
- If the fuel tank is equipped with a shut-off valve, make sure it is open.
- If the engine is equipped with an in-line fuel filter, make sure it is clean and unobstructed. Replace the filter if necessary.
- Make sure fuel is reaching the carburetor. This includes checking the fuel lines and fuel pump for restrictions or faulty components, replace as necessary.
- Make sure the air cleaner element is clean and all air cleaner element components are fastened securely.

If, after checking the items listed above, the engine is hard to start, runs roughly, or stalls at low idle speed, it may be necessary to adjust or service the carburetor.

Adjust Carburetor

There are no accessible mixture adjustment screws on the carburetor. The only setting which can be changed is the low idle speed.

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before making final settings (steps 2 and 3).
2. **Low Idle Speed Setting:** Place the throttle control into the **"idle"** or **"slow"** position. Set the low idle speed to **1200 RPM*** (± 75 RPM) by turning the low idle speed adjusting screw **in** or **out**. Check the speed using a tachometer.

   *NOTE: The actual low idle speed depends on the application – refer to equipment manufacturers recommendations. The standard low idle speed is 1200 RPM.
3. If proper operation is not restored after adjusting the low idle speed, carburetor servicing by an authorized Kohler Engine Service Dealer may be required.

Electronic Fuel Injection (EFI) System

The EFI system is a complete, electronically-controlled fuel management system, designed to deliver a precisely controlled fuel flow under all operating conditions. The electronic control unit (ECU), the "brain" of the system, automatically adjusts fuel delivery and ignition timing based upon load, speed, operating temperature, and exhaust emission levels. The low idle speed is the only manual adjustment possible.

The ECU continuously monitors operation of the EFI system. If it detects a problem or fault within the system, it will illuminate the malfunction indicator light (MIL), which is mounted in view of the operator. This is a signal that normal, programmed operation has been affected, and service by an authorized Kohler Engine Dealer is required.

NOTE: The EFI system requires a rather complex wiring harness to carry the electrical signals between the sensors and the ECU. **Do not** spray water at the wiring harness or any of the electrical components, especially the ECU, as it could cause malfunction, damage, or failure.

Troubleshooting

If the MIL comes on, or the engine becomes hard to start, runs roughly, or stalls at low idle speed, initial checks should be made in the following areas:

- Make sure the fuel tank is filled with clean, fresh gasoline, and shut-off valve (if so equipped) is opened completely.
- Make sure fuel tank vent cap is not blocked and it is operating properly.
- Make sure the air cleaner element and precleaner are clean and all components are properly secured. Clean or replace as necessary.

- Make sure the proper fuel filter is being used, and it is clean and unobstructed. Replace filter **only** with genuine Kohler parts.

- Make sure all connections to sensors, ECU, and fuel injectors are properly secured.

- Make sure a good 12 volt battery is being used and is fully charged.

If these checks do not correct the problem, or the MIL remains on, further diagnosis and servicing by an authorized Kohler Engine Dealer is necessary.

Adjustment – EFI Throttle Body

Low Idle Speed (RPM) is the only adjustment that can be made. All other fuel calibrations are permanently preset and controlled by the ECU. The standard low idle speed is **1500 RPM*** (+ 75 RPM).

*NOTE: The actual low idle speed depends on the application -- refer to equipment manufacturer's recommendations.

When an EFI engine is started cold, the ECU will be using internal programming for cold running, and the idle speed may vary from the manual setting. Do not attempt to perform any readjustment during this "warm-up" period.

If adjustment is to be made, the engine must be at operating temperature, air cleaner in place, and check engine light must be off (no fault codes present).

1. Start the engine and run at half throttle for 5 to 10 minutes to warm up.

2. Place the throttle control into the **"idle"** or **"slow"** position.

3. Turn the low idle speed adjusting screw in or out and check RPM with a tachometer. See Figure 17.

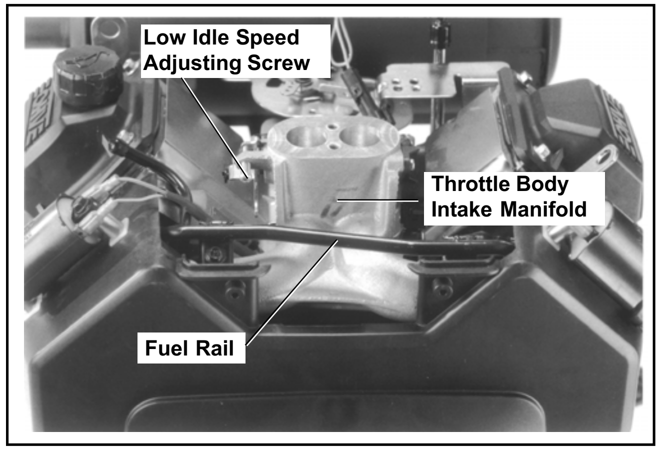


Figure 17. EFI Throttle Body Manifold.

Troubleshooting

When troubles occur, be sure to check the simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank. Some common causes of engine troubles are listed in the following table.

Do not attempt to service or replace major engine components, or any items that require special timing or adjustment procedures. Have your Kohler Engine Service Dealer do this work.

Possible Cause / Problem	No Fuel	Improper Fuel	Dirt In Fuel Line/System	Dirty Grass Screen	Incorrect Oil Level	Engine Overloaded	Dirty Air Cleaner	Faulty Spark Plug
Will Not Start	•	•	•		•	•	•	•
Hard Starting		•	•		•	•	•	•
Stops Suddenly	•		•	•	•	•	•	
Lacks Power		•	•	•	•	•	•	•
Operates Erratically		•	•	•		•	•	•
Knocks or Pings		•		•		•		•
Skips or Misfires		•	•	•			•	•
Backfires			•			•	•	•
Overheats			•	•	•	•	•	
High Fuel Consumption						•	•	•

Storage

If the engine will be out of service for two months or more, use the following storage procedure:

1. Clean the exterior surfaces of the engine. On EFI engines, avoid spraying water at the wiring harness or any of the electrical components.

2. Change the oil and filter while the engine is still warm from operation. See “Change Oil and Oil Filter” on page 9.

3. The fuel system must be completely emptied, or the gasoline must be treated with a stabilizer to prevent deterioration. If you choose to use a stabilizer, follow the manufacturers recommendations, and add the correct amount for the capacity of the fuel system. Fill the fuel tank with clean, fresh gasoline. Run the engine for 2-3 minutes to get stabilized fuel into the rest of the system. Close fuel shut-off valve when unit is being stored or transported.

   To empty the system, run the engine until the tank and system are empty.

4. Remove the spark plugs. Add one tablespoon of engine oil into each spark plug hole. Install the plugs, but do not connect the plug leads. Crank the engine two or three revolutions.

5. On units with EFI engines, disconnect the negative (-) battery cable or use a "battery minder" trickle charger while the unit is in storage.

6. Store the engine in a clean, dry place.

Parts Ordering

The engine Specification, Model, and Serial Numbers are required when ordering replacement parts from your Kohler Engine Service Dealer. These numbers are found on the identification plate which is affixed to the engine shrouding. Include letter suffixes if there are any. See “Engine Identification Numbers” on page 6.

Always insist on genuine Kohler parts. All genuine Kohler parts meet strict standards for fit, reliability, and performance.

Major Repair

Major repair information is available in Kohler Engine Service Manuals. However, major repair generally requires the attention of a trained mechanic and the use of special tools and equipment. Your Kohler Engine Service Dealer has the facilities, training, and genuine Kohler replacement parts necessary to perform this service. For Sales & Service assistance call 1-800-544-2444 (U.S. & Canada) or contact your Kohler Engine Dealer or Service Distributor, they're in the Yellow Pages under Engines-Gasoline.

Specifications

Model:		CH18,20,22	CH25,26,730,740,745
Bore:	mm (in.)	77 (3.03)[#]	83 (3.27)
Stroke:	mm (in.)	67 (2.64)	67 (2.64)
Displacement:	cm^3 (in^3)	624 (38.1)[#]	725 (44.0)
Power (@3600 RPM):	kW (HP)	13.4 (18*)/14.9 (20*)/16.4 (22*)	18.4 (25*)/19.4 (26*) 18.6 (25*)/20.1 (27*)/20.9(28*)
Max. Peak Torque (@ RPM):	N·m (ft. lb.)	43.7 (32.2) @2200 44.3 (32.7) @2400 50.6 (37.3) @2400	54 (39.5) @2200 54.2 (40.0) @2800 53.7 (39.6) @2600 58.6 (43.2) @2400 57.9 (42.7) @2600
Compression Ratio:		8.5:1	9.0:1
Weight:	kg (lb.)	41 (90)	43 (94)
Lubrication:		Full Pressure w/full Flow Filter	
Oil Capacity (w/filter) - approximate, determined by oil filter and oil cooler used:		1.6-1.8 L (1.7-1.9 U.S. qt.)	

Exhaust Emission Control System for models CH18,20,22,23,25,730,740 is EM.
Exhaust Emission Control System for models CH26 and CH745 are EM, O2S, ECM, MFI.

*Horsepower ratings exceed Society of Automotive Engineers Small Engine Test Code J1940. Actual engine horsepower is lower and affected by, but not limited to, accessories (air cleaner, exhaust, charging, cooling, fuel pump, etc.), application, engine speed and ambient operating conditions (temperature, humidity, and altitude). Kohler reserves the right to change product specifications, designs and equipment without notice and without incurring obligation.

[#]CH22 or CH23 engines with Spec. Numbers of 765xx have bore size of 80 mm (3.15 in.) and displacement of 674 cm^3 (41.1 in^3).

LIMITED 2 YEAR COMMAND ENGINE WARRANTY

Kohler Co. warrants to the original consumer that each new COMMAND engine sold by Kohler Co. will be free from manufacturing defects in materials or workmanship in normal service for a period of two (2) years from date of purchase, provided it is operated and maintained in accordance with Kohler Co.'s instructions and manuals.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us of such parts as inspection shall disclose to have been defective.

EXCLUSIONS:
Mufflers on engines used commercially (non-residential) are warranted for one (1) year from date of purchase, except catalytic mufflers, which are warranted for two (2) years.

This warranty does not apply to defects caused by casualty or unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty:

Engine accessories such as fuel tanks, clutches, transmissions, power-drive assemblies, and batteries, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

KOHLER CO. AND/OR THE SELLER SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to labor costs or transportation charges in connection with the repair or replacement of defective parts.

IMPLIED OR STATUTORY WARRANTIES, INCLUDING WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is any one authorized to make any on our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

TO OBTAIN WARRANTY SERVICE:
Purchaser must bring the engine to an authorized Kohler service facility. To locate the nearest facility, visit our website, www.kohlerengines.com, and click on SALES AND SERVICES to use the locator function, consult your Yellow Pages or telephone 1-800-544-2444.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

KOHLER CO.
FEDERAL AND CALIFORNIA EMISSION CONTROL SYSTEMS
LIMITED WARRANTY
SMALL OFF-ROAD ENGINES

The U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and Kohler Co. are pleased to explain the Federal and California Emission Control Systems Warranty on your small off-road equipment engine. For California, engines produced in 1995 and later must be designed, built and equipped to meet the state's stringent anti-smog standards. In other states, 1997 and later model year engines must be designed, built and equipped, to meet the U.S. EPA regulations for small non-road engines. The engine must be free from defects in materials and workmanship which cause it to fail to conform with U.S. EPA standards for the first two years of engine use from the date of sale to the ultimate purchaser. Kohler Co. must warrant the emission control system on the engine for the period of time listed above, provided there has been no abuse, neglect or improper maintenance.

The emission control system may include parts such as the carburetor or fuel injection system, the ignition system, and catalytic converter. Also included are the hoses, belts and connectors and other emission related assemblies.

Where a warrantable condition exists, Kohler Co. will repair the engine at no cost, including diagnosis (if the diagnostic work is performed at an authorized dealer), parts and labor.

MANUFACTURER'S WARRANTY COVERAGE
Engines produced in 1995 or later are warranted for two years in California. In other states, 1997 and later model year engines are warranted for two years. If any emission related part on the engine is defective, the part will be repaired or replaced by Kohler Co. free of charge.

OWNER'S WARRANTY RESPONSIBILITIES

(a) The engine owner is responsible for the performance of the required maintenance listed in the owner's manual. Kohler Co. recommends that you retain all receipts covering maintenance on the engine, but Kohler Co. cannot deny warranty solely for the lack of receipts or for your failure to assure that all scheduled maintenance was performed.

(b) Be aware, however, that Kohler Co. may deny warranty coverage if the engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

Continued on next page.

(c) For warranty repairs, the engine must be presented to a Kohler Co. service center as soon as a problem exists. Call 1-800-544-2444 or access our website at: www.kohlerengines.com, for the names of the nearest service centers. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

If you have any questions regarding warranty rights and responsibilities, you should contact Kohler Co. at 1-920-457-4441 and ask for an Engine Service representative.

COVERAGE
Kohler Co. warrants to the ultimate purchaser and each subsequent purchaser that the engine will be designed, built and equipped, at the time of sale, to meet all applicable regulations. Kohler Co. also warrants to the initial purchaser and each subsequent purchaser, that the engine is free from defects in materials and workmanship which cause the engine to fail to conform with applicable regulations for a period of two years.

Engines produced in 1995 or later are warranted for two years in California. For 1997 and later model years, EPA requires manufacturers to warrant engines for two years in all other states. These warranty periods will begin on the date the engine is purchased by the initial purchaser. If any emission related part on the engine is defective, the part will be replaced by Kohler Co. at no cost to the owner. Kohler Co. is liable for damages to other engine components caused by the failure of a warranted part still under warranty.

Kohler Co. shall remedy warranty defects at any authorized Kohler Co. engine dealer or warranty station. Warranty repair work done at an authorized dealer or warranty station shall be free of charge to the owner if such work determines that a warranted part is defective.

Listed below are the parts covered by the Federal and California Emission Control Systems Warranty. Some parts listed below may require scheduled maintenance and are warranted up to the first scheduled replacement point for that part. The warranted parts are:

- Carburetor assembly
- Throttle body (EFI Systems)
- Catalytic muffler (if equipped)
- Fuel metering valve (if equipped)
- Crankcase breather
- Fuel pressure regulator (EFI Systems)
- Ignition module(s) with high tension lead
- Spark advance module (if equipped)
- Oxygen, speed, throttle position, and temperature sensors (if equipped)
- Electronic control unit (if equipped)
- Fuel injectors (EFI Systems)
- Air filter, fuel filter, and spark plugs (only to first scheduled replacement point)

LIMITATIONS
This Emission Control Systems Warranty shall not cover any of the following:

(a) repair or replacement required because of misuse or neglect, improper maintenance, repairs improperly performed or replacements not conforming to Kohler Co. specifications that adversely affect performance and/or durability and alterations or modifications not recommended or approved in writing by Kohler Co.,

(b) replacement of parts and other services and adjustments necessary for required maintenance at and after the first scheduled replacement point,

(c) consequential damages such as loss of time, inconvenience, loss of use of the engine or equipment, etc.,

(d) diagnosis and inspection fees that do not result in eligible warranty service being performed, and

(e) any add-on or modified part, or malfunction of authorized parts due to the use of add-on or modified parts.

MAINTENANCE AND REPAIR REQUIREMENTS
The owner is responsible for the proper use and maintenance of the engine. Kohler Co. recommends that all receipts and records covering the performance of regular maintenance be retained in case questions arise. If the engine is resold during the warranty period, the maintenance records should be transferred to each subsequent owner. Kohler Co. reserves the right to deny warranty coverage if the engine has not been properly maintained; however, Kohler Co. may not deny warranty repairs solely because of the lack of repair maintenance or failure to keep maintenance records.

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, **warranty repairs must be performed by a Kohler authorized service center**. Any replacement part or service that is equivalent in performance and durability may be used in non-warranty maintenance or repairs, and shall not reduce the warranty obligations of the engine manufacturer.

KOHLER ENGINES

FORM NO.:	24 590 01
ISSUED:	11/04
REVISED:	1/05
MAILED:	

LITHO IN U.S.A.

FOR SALES AND SERVICE INFORMATION
IN U.S. AND CANADA, CALL **1-800-544-2444**

1P24 590 01

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ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

SERVICE MANUAL

KOHLER® COMMAND CH18-745

HORIZONTAL CRANKSHAFT

KOHLER®
engines

Section 1
Safety and General Information

Safety Precautions

To ensure safe operation please read the following statements and understand their meaning. Also refer to your equipment manufacturer's manual for other important safety information. This manual contains safety precautions which are explained below. Please read carefully.

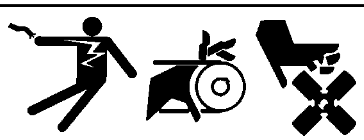
WARNING
Warning is used to indicate the presence of a hazard that *can* cause *severe* personal injury, death, or substantial property damage if the warning is ignored.

CAUTION
Caution is used to indicate the presence of a hazard that *will* or *can* cause *minor* personal injury or property damage if the caution is ignored.

NOTE
Note is used to notify people of installation, operation, or maintenance information that is important but not hazard-related.

For Your Safety!
These precautions should be followed at all times. Failure to follow these precautions could result in injury to yourself and others.

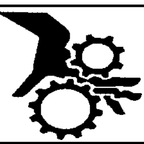
WARNING



Accidental Starts can cause severe injury or death.

Disconnect and ground spark plug leads before servicing.

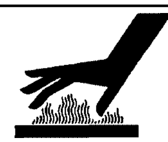
WARNING



Rotating Parts can cause severe injury.

Stay away while engine is in operation.

WARNING



Hot Parts can cause severe burns.

Do not touch engine while operating or just after stopping.

Accidental Starts!
Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Rotating Parts!
Keep hands, feet, hair, and clothing away from all moving parts to prevent injury. Never operate the engine with covers, shrouds, or guards removed.

Hot Parts!
Engine components can get extremely hot from operation. To prevent severe burns, do not touch these areas while the engine is running - or immediately after it is turned off. Never operate the engine with heat shields or guards removed.

Section 1
Safety and General Information

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Stop engine before filling fuel tank.

Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

⚠ WARNING

Cleaning Solvents can cause severe injury or death.

Use only in well ventilated areas away from ignition sources.

Flammable Solvents!
Carburetor cleaners and solvents are extremely flammable. Keep sparks, flames, and other sources of ignition away from the area. Follow the cleaner manufacturer’s warnings and instructions on its proper and safe use. Never use gasoline as a cleaning agent.

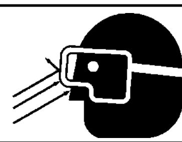
⚠ WARNING

Carbon Monoxide can cause severe nausea, fainting or death.

Do not operate engine in closed or confined area.

Lethal Exhaust Gases!
Engine exhaust gases contain poisonous carbon monoxide. Carbon monoxide is odorless, colorless, and can cause death if inhaled. Avoid inhaling exhaust fumes, and never run the engine in a closed building or confined area.

⚠ WARNING

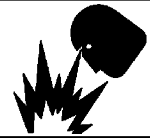


Uncoiling Spring can cause severe injury.

Wear safety goggles or face protection when servicing retractable starter.

Spring Under Tension!
Retractable starters contain a powerful, recoil spring that is under tension. Always wear safety goggles when servicing retractable starters and carefully follow instructions in the "Retractable Starter" Section 7 for relieving spring tension.

⚠ WARNING



Explosive Gas can cause fires and severe acid burns.

Charge battery only in a well ventilated area. Keep sources of ignition away.

Explosive Gas!
Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sparks, open flames, and other sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

⚠ CAUTION

Electrical Shock can cause injury.

Do not touch wires while engine is running.

Electrical Shock!
Never touch electrical wires or components while the engine is running. They can be sources of electrical shock.

Engine Identification Numbers

When ordering parts, or in any communication involving an engine, always give the **Model, Specification and Serial Numbers,** including letter suffixes if there are any.

The engine identification numbers appear on a decal, or decals, affixed to the engine shrouding. See Figure 1-1. An explanation of these numbers is shown in Figure 1-2.

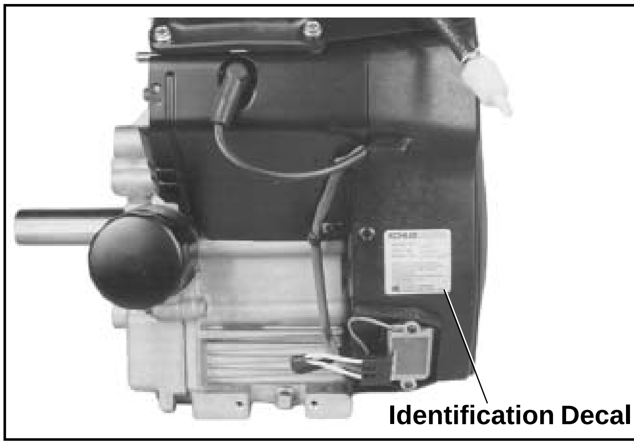


Figure 1-1. Engine Identification Decal Location.

A. Model No. **C H 18 S**

- **Command Engine** — C
- **Horizontal Crankshaft** — H
- **Numerical Designation** (730, 740, 745) **or** **Horsepower** — 18
  - 17 = 17 HP
  - 18 = 18 HP
  - 20 = 20 HP
  - 22 = 22 HP
  - 23 = 23 HP
  - 25 = 25 HP
  - 26 = 26 HP
- **Version Code** — S
  - S = Electric Start

B. Spec. No. **62500** — or — **CH730-0001**, **CH740-0001**, **CH745-0001**
Complete Spec Number (Incorporating Model No. with Variation No. of Basic Spec.)

- **Engine Model Code** — 62
- **Variation of Basic Engine** — 500

Code	**Model**	
62	CH18	
64	CH20	
66	CH22	(624 cc)
68	CH25	
76	CH22/23	(674 cc)
78	CH26	

C. Serial No. **3305810334**

- **Year Manufactured Code** — 33
- **Factory Code** — 05

Code	**Year**	**Code**	**Year**
21	1991	30	2000
22	1992	31	2001
23	1993	32	2002
24	1994	33	2003
25	1995	34	2004
26	1996	35	2005
27	1997		
28	1998		
29	1999		

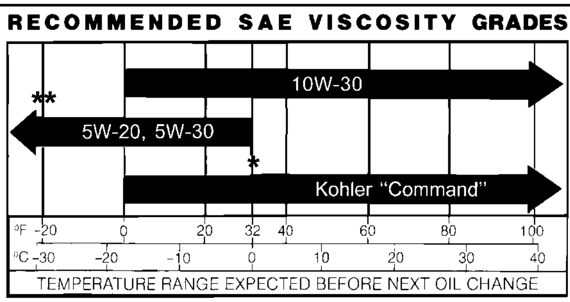
Figure 1-2. Explanation of Engine Identification Numbers.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important. So is checking oil daily and changing oil regularly. Failure to use the correct oil, or using dirty oil, causes premature engine wear and failure.

Oil Type

Use high-quality detergent oil of **API (American Petroleum Institute) Service Class SG, SH, SJ or higher.** Select the viscosity based on the air temperature at the time of operation as shown in the following table.



*Use of synthetic oil having 5W-20 or 5W-30 rating is acceptable, up to 40°F.
**Synthetic oils will provide better starting in extreme cold (below -10°F).

NOTE: Using other than service class SG, SH, SJ or higher oil or extending oil change intervals longer than recommended can cause engine damage.

NOTE: Synthetic oils meeting the listed classifications may be used with oil changes performed at the recommended intervals. However, to allow piston rings to properly seat, a new or rebuilt engine should be operated for at least 50 hours using standard petroleum based oil before switching to synthetic oil.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 1-3.

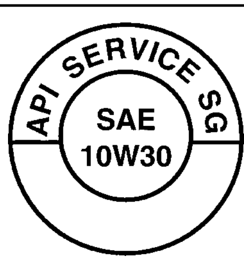


Figure 1-3. Oil Container Logo.

Refer to Section 6 - "Lubrication System" for detailed procedures on checking the oil, changing the oil and changing the oil filter.

Fuel Recommendations

WARNING: Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Before servicing the fuel system, make sure there are no sparks, open flames or other sources of ignition nearby as these can ignite gasoline vapors. Disconnect and ground the spark plug leads to prevent the possibility of sparks from the ignition system.

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.

Do not add oil to the gasoline.

Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Unleaded gasoline is recommended as it leaves less combustion chamber deposits and reduces harmful exhaust emissions. Leaded gasoline is not recommended and ***must not*** be used on EFI engines, or on other models where exhaust emissions are regulated.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Periodic Maintenance Instructions

WARNING: Accidental Starts!
Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

Maintenance Schedule

These required maintenance procedures should be performed at the frequency stated in the table. They should also be included as part of any seasonal tune-up.

Frequency	Maintenance Required	Refer to:
Daily or Before Starting Engine	• Fill fuel tank. • Check oil level. • Check air cleaner for dirty[1], loose, or damaged parts. • Check air intake and cooling areas, clean as necessary[1].	Section 5 Section 6 Section 4 Section 4
Every 25 Hours	• Service precleaner element[1].	Section 4
Every 100 Hours	• Replace air cleaner element[1]. • Change oil. (More frequently under severe conditions.) • Remove cooling shrouds and clean cooling areas[1,3]. • Check oil cooler fins, clean as necessary (if equipped).	Section 4 Section 6 Section 4 Section 6
Every 200 Hours	• Check spark plug condition and gap. • Change oil filter.	Section 8 Section 6
Every 250 Hours	• Replace heavy-duty air cleaner element and check inner element[1].	Section 4
Annually or Every 500 Hours	• Have bendix starter drive serviced[2]. • Have solenoid shift starter disassembled and cleaned[2].	Section 8 Section 8
Every 500 Hours	• Have crankshaft spline lubricated[2].	Section 2
Every 1500 Hours	• Replace fuel filter[1] (EFI engines).	Section 5B

[1]Perform these maintenance procedures more frequently under extremely dusty, dirty conditions.
[2]Have a Kohler Engine Service Dealer perform this service.
[3]Cleanout Kits 25 755 20-S (black) or 25 755 21-S (gold) allow cooling areas to be cleaned without removing shrouds.

Storage

If the engine will be out of service for two months or more, use the following storage procedure.

1. Clean the exterior surfaces of the engine. On Electronic Fuel Injected (EFI) engines, avoid spraying water at the wiring harness or any of the electrical components.

2. Change the oil and oil filter while the engine is still warm from operation. See “Change Oil and Oil Filter” in Section 6.

3. The fuel system must be completely emptied, or the gasoline must be treated with a stabilizer to prevent deterioration. If you choose to use a stabilizer, follow the manufacturer’s recommendations, and add the correct amount for the capacity of the fuel system.

   Fill the fuel tank with clean, fresh gasoline. Run the engine for 2 to 3 minutes to get stabilized fuel into the rest of the system. Close the fuel shut-off valve when the unit is being stored or transported.

   To empty the system, run the engine until the tank and the system are empty.

4. Remove the spark plugs and add one tablespoon of engine oil into each spark plug hole. Install the spark plugs, but do not connect the plug leads. Crank the engine two or three revolutions.

5. On equipment with an EFI engine, disconnect the battery or use a battery minder to keep the battery charged during storage.

6. Store the engine in a clean, dry place.

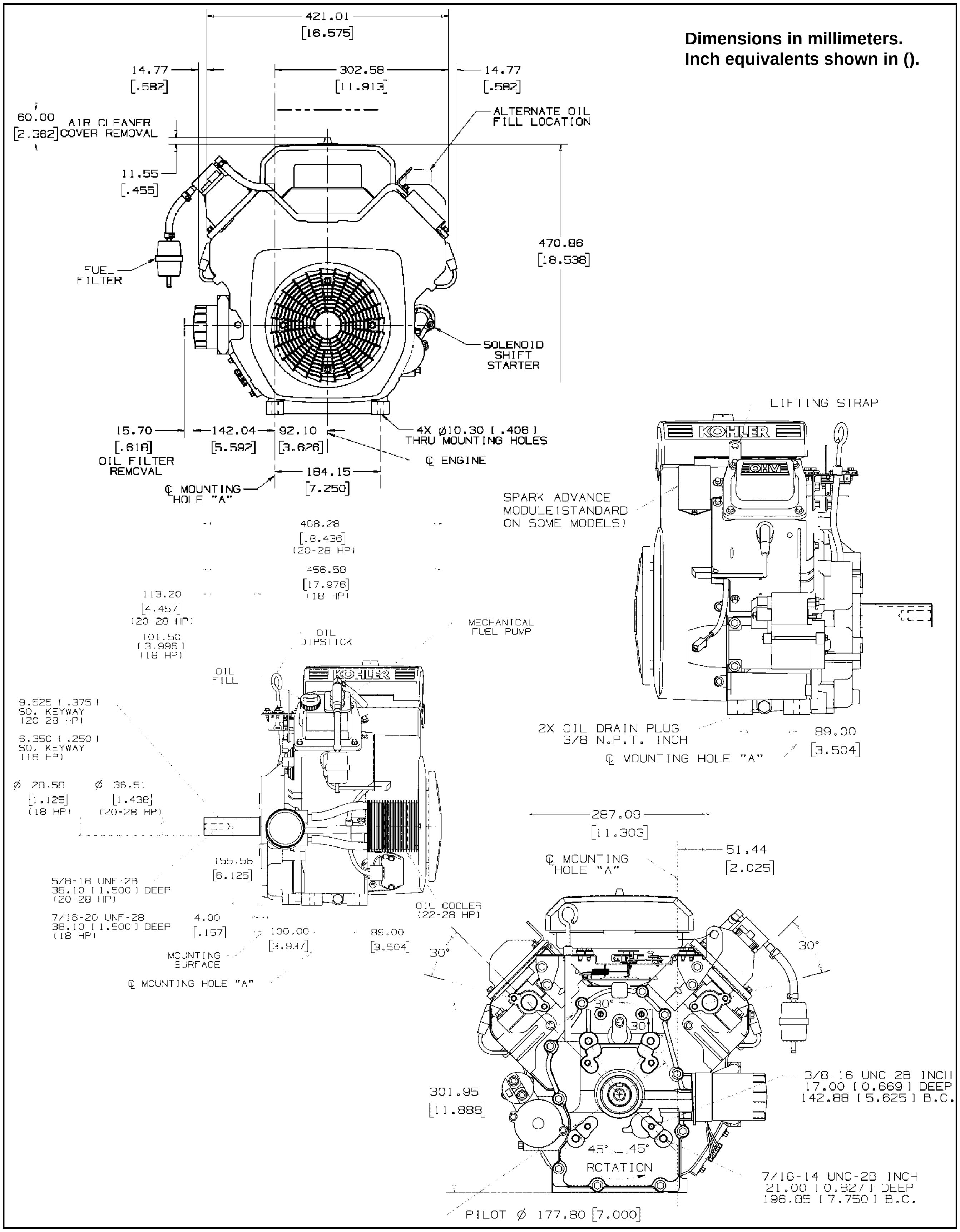


Figure 1-4. Typical Engine Dimensions CH Series with Standard Flat Air Cleaner.

Dimensions in millimeters.
Inch equivalents shown in ().

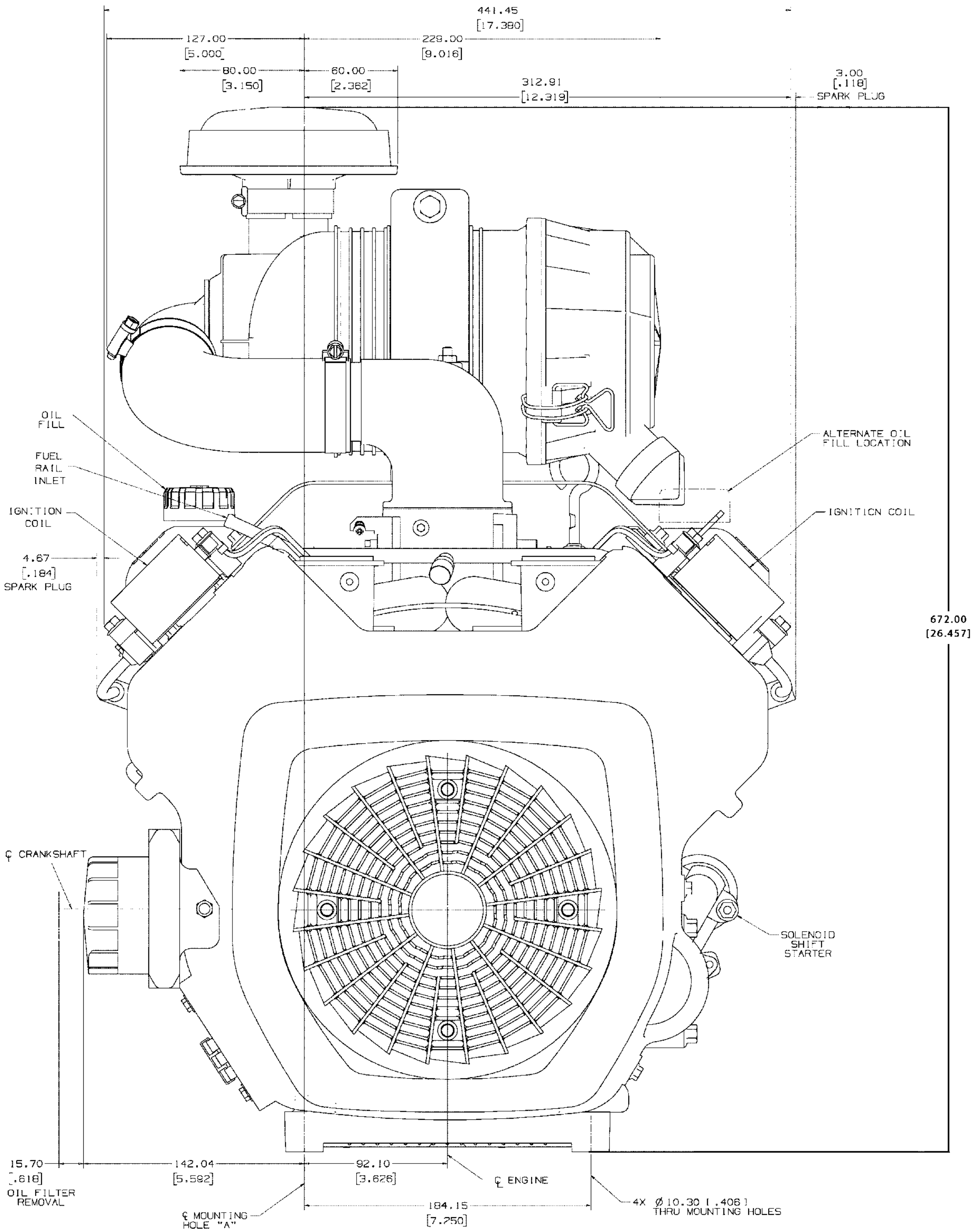


Figure 1-5. Typical Engine Dimensions CH EFI Series with Heavy-Duty Air Cleaner.

General Specifications[1]

Power (@ 3600 RPM, corrected to SAE J1995)

CH18	13.4 kW (18 HP)
CH20	14.9 kW (20 HP)
CH22/23	16.4 kW (22 HP)
CH25, CH730	18.4 kW (25 HP)
CH26	19.4 kW (26 HP)
CH740	20.1 kW (27 HP)
CH745	20.9 kW (28 HP)

Peak Torque

CH18 - @ 2200 RPM	44.4 N·m (32.8 ft. lb.)
CH20 - @ 2600 RPM	44.2 N·m (32.6 ft. lb.)
CH22/23 - @ 2200 RPM	51.7 N·m (38.2 ft. lb.)
CH25, CH730 - @ 2800 RPM	54.1 N·m (39.9 ft. lb.)
CH26 - @ 2800 RPM	54.2 N·m (40.0 ft. lb.)
CH740 - @ 3000 RPM	57.9 N·m (42.7 ft. lb.)
CH745 - @ 2200 RPM	60.7 N·m (44.8 ft. lb.)

Bore

CH18, CH20, CH22 (624 cc)	77 mm (3.03 in.)
CH22/23 (674 cc)	80 mm (3.15 in.)
CH25, CH26, CH730-745	83 mm (3.27 in.)

Stroke .... 67 mm (2.64 in.)

Displacement

CH18, CH20, CH22 (624 cc)	624 cc (38 cu. in.)
CH22/23 (674 cc)	674 cc (41 cu. in.)
CH25, CH26, CH730-745	725 cc (44 cu. in.)

Compression Ratio

CH18, CH20, CH22/23	8.5:1
CH25, CH26, CH730-745	9.0:1

Dry Weight

CH18, CH20, CH22/23	41 kg (90 lb.)
CH25, CH26, CH730-745	43 kg (94 lb.)

Oil Capacity (with filter)

CH18, CH20, CH22/23, CH25, CH26, CH730-745	1.9 L (2.0 U.S. qt.)

Angle of Operation - Maximum (At Full Oil Level) All Directions .... 25°

Blower Housing and Sheet Metal

M5 Fasteners Torque .... 4.0 N·m (35 in. lb.)

M6 Fasteners Torque .... 6.8 N·m (60 in. lb.)

Rectifier-Regulator Fastener Torque .... 4.0 N·m (35 in. lb.)

[1]Values are in Metric units. Values in parentheses are English equivalents. Lubricate threads with engine oil prior to assembly.

1

Camshaft
End Play (With Shim) .... 0.076/0.127 mm (0.0030/0.0050 in.)

Running Clearance .... 0.025/0.063 mm (0.0010/0.0025 in.)

Bore I.D.
New .... 20.000/20.025 mm (0.7874/0.7884 in.)
Max. Wear Limit .... 20.038 mm (0.7889 in.)

Camshaft Bearing Surface O.D.
New .... 19.962/19.975 mm (0.7859/0.7864 in.)
Max. Wear Limit .... 19.959 mm (0.7858 in.)

Carburetor and Intake Manifold
Intake Manifold Mounting Fastener Torque
Torque in Two Stages .... initially to 7.4 N·m (66 in. lb.)
finally to 9.9 N·m (88 in. lb.)

Carburetor Mounting Screw Torque M6 .... 6.2-7.3 N·m (55-65 in. lb.)

Adapter (for Heavy Duty Air Cleaner) Mounting Fastener Torque .... 7.3 N·m (65 in. lb.)

Connecting Rod
Cap Fastener Torque (torque in increments)
8 mm straight shank .... 22.7 N·m (200 in. lb.)
8 mm step-down .... 14.7 N·m (130 in. lb.)
6 mm straight shank .... 11.3 N·m (100 in. lb.)

Connecting Rod-to-Crankpin Running Clearance
New .... 0.030/0.055 mm (0.0012/0.0022 in.)
Max. Wear Limit .... 0.070 mm (0.0028 in.)

Connecting Rod-to-Crankpin Side Clearance .... 0.26/0.63 mm (0.0102/0.0248 in.)

Connecting Rod-to-Piston Pin Running Clearance .... 0.015/0.028 mm (0.0006/0.0011 in.)

Piston Pin End I.D.
New .... 17.015/17.023 mm (0.6699/0.6702 in.)
Max. Wear Limit .... 17.036 mm (0.6707 in.)

Crankcase
Governor Cross Shaft Bore I.D.
6 mm Shaft
New .... 6.025/6.050 mm (0.2372/0.2382 in.)
Max. Wear Limit .... 6.063 mm (0.2387 in.)
8 mm Shaft
New .... 8.025/8.075 mm (0.3159/0.3179 in.)
Max. Wear Limit .... 8.088 mm (0.3184 in.)

Breather Cover Fastener Torque .... 7.3 N·m (65 in. lb.)

Oil Drain Plug Torque .... 13.6 N·m (10 ft. lb.)

Closure Plate
Closure Plate Fastener Torque .... 24.4 N·m (216 in. lb.)

Crankshaft
End Play (Free) .... 0.070/0.590 mm (0.0028/0.0230 in.)

End Play (With Thrust Bearing Components) .... 0.070/0.270 mm (0.0028/0.0100 in.)
Except CH25 Engines Below Serial No. 2403500008 .... 0.050/0.750 mm (0.0020/0.0295 in.)

Crankshaft Bore (In Crankcase)
New .... 40.965/41.003 mm (1.6128/1.6143 in.)
Max. Wear Limit .... 41.016 mm (1.6148 in.)

Crankshaft to Sleeve Bearing (Crankcase)
Running Clearance - New .... 0.03/0.09 mm (0.0012/0.0035 in.)

Crankshaft Bore (In Closure Plate) - New .... 40.987/40.974 mm (1.6136/1.6131 in.)

Crankshaft Bore (In Closure Plate)-to-Crankshaft
Running Clearance - New .... 0.039/0.074 mm (0.0015/0.0029 in.)

Flywheel End Main Bearing Journal
O.D. - New .... 40.913/40.935 mm (1.6107/1.6116 in.)
O.D. - Max. Wear Limit .... 40.84 mm (1.608 in.)
Max. Taper .... 0.022 mm (0.0009 in.)
Max. Out-of-Round .... 0.025 mm (0.0010 in.)

Closure Plate End Main Bearing Journal
O.D. - New .... 40.913/40.935 mm (1.6107/1.6116 in.)
O.D. - Max. Wear Limit .... 40.84 mm (1.608 in.)
Max. Taper .... 0.022 mm (0.0009 in.)
Max. Out-of-Round .... 0.025 mm (0.0010 in.)

Connecting Rod Journal
O.D. - New .... 35.955/35.973 mm (1.4156/1.4163 in.)
O.D. - Max. Wear Limit .... 35.94 mm (1.415 in.)
Max. Taper .... 0.018 mm (0.0007 in.)
Max. Out-of-Round .... 0.025 mm (0.0010 in.)

Crankshaft T.I.R.
PTO End, Crank in Engine .... 0.279 mm (0.0110 in.)
Entire Crank, in V-Blocks .... 0.10 mm (0.0039 in.)

Cylinder Bore
Cylinder Bore I.D.
New - CH18, CH20, CH22 (624 cc) .... 77.000/77.025 mm (3.0315/3.0325 in.)
New - CH22/23 (674 cc) .... 80.000/80.025 mm (3.1496/3.1506 in.)
New - CH25, CH26, CH730-745 .... 82.988/83.013 mm (3.2672/3.2682 in.)
Max. Wear Limit - CH18, CH20, CH22 (624 cc) .... 77.063 mm (3.0340 in.)
Max. Wear Limit - CH22/23 (674 cc) .... 80.065 mm (3.1522 in.)
Max. Wear Limit - CH25, CH26, CH730-745 .... 83.051 mm (3.2697 in.)
Max. Out-of-Round .... 0.12 mm (0.0047 in.)
Max. Taper .... 0.05 mm (0.0020 in.)

Cylinder Head

Cylinder Head Fastener Torque	
Hex. Flange Nut - Torque in Two Stages	initially to 16.9 N·m (150 in. lb.) finally to 33.9 N·m (300 in. lb.)
Head Bolt - Torque in Two Stages	initially to 22.6 N·m (200 in. lb.) finally to 41.8 N·m (370 in. lb.)
Max. Out-of-Flatness	0.076 mm (0.003 in.)
Rocker Arm Screw Torque	11.3 N·m (100 in. lb.)

Fan/Flywheel

Fan Fastener Torque	9.9 N·m (88 in. lb.)
Flywheel Retaining Screw Torque	66.4 N·m (49 ft. lb.)

Governor

Governor Cross Shaft-to-Crankcase Running Clearance	
6 mm Shaft	0.013/0.075 mm (0.0005/0.0030 in.)
8 mm Shaft	0.025/0.126 mm (0.0009/0.0049 in.)
Governor Cross Shaft O.D.	
6 mm Shaft	
New	5.975/6.012 mm (0.2352/0.2367 in.)
Max. Wear Limit	5.962 mm (0.2347 in.)
8 mm Shaft	
New	7.949/8.000 mm (0.3129/.3149 in.)
Max. Wear Limit	7.936 mm (0.3124 in.)
Governor Gear Shaft-to-Governor Gear Running Clearance	0.015/0.140 mm (0.0006/0.0055 in.)
Governor Gear Shaft O.D.	
New	5.990/6.000 mm (0.2358/0.2362 in.)
Max. Wear Limit	5.977 mm (0.2353 in.)
Governor Lever Nut Torque	6.8 N·m (60 in. lb.)

Ignition

Spark Plug Type (Champion® or Equivalent)	RC12YC or Platinum 3071
Spark Plug Gap	0.76 mm (0.030 in.)
Spark Plug Torque	24.4-29.8 N·m (18-22 ft. lb.)
Ignition Module Air Gap	0.28/0.33 mm (0.011/0.013 in.)
Ignition Module Fastener Torque	4.0-6.2 N·m (35-55 in. lb.)
Speed Sensor Air Gap (EFI engines)	1.250/1.750 mm (0.049/0.068 in.)

Muffler

Muffler Retaining Nut Torque .... 24.4 N·m (216 in. lb.)

Oil Filter

Oil Filter Torque .... 10.4-12.7 N·m (90-110 in. lb.)

Oil Cooler

Oil Cooler/Adapter Nipple Torque .... 27 N·m (20 ft. lb.)

Piston, Piston Rings, and Piston Pin

Piston-to-Piston Pin Running Clearance .... 0.006/0.017 mm (0.0002/0.0007 in.)

Piston Pin Bore I.D.
- New .... 17.006/17.012 mm (0.6695/0.6698 in.)
- Max. Wear Limit .... 17.025 mm (0.6703 in.)

Piston Pin O.D.
- New .... 16.995/17.000 mm (0.6691/0.6693 in.)
- Max. Wear Limit .... 16.994 mm (0.6691 in.)

Top Compression Ring-to-Groove Side Clearance
- CH18, CH20, CH22 (624 cc) .... 0.040/0.080 mm (0.0016/0.0031 in.)
- CH22/23 (674 cc) .... 0.030/0.076 mm (0.0012/0.0030 in.)
- CH25, CH26, CH730-745 .... 0.025/0.048 mm (0.0010/0.0019 in.)

Middle Compression Ring-to-Groove Side Clearance
- CH18, CH20, CH22 (624 cc) .... 0.040/0.080 mm (0.0016/0.0031 in.)
- CH22/23 (674 cc) .... 0.030/0.076 mm (0.0012/0.0030 in.)
- CH25, CH26, CH730-745 .... 0.015/0.037 mm (0.0006/0.0015 in.)

Oil Control Ring-to-Groove Side Clearance
- CH18, CH20, CH22 (624 cc) .... 0.060/0.202 mm (0.0024/0.0080 in.)
- CH22/23 (674 cc) .... 0.046/0.196 mm (0.0018/0.0077 in.)
- CH25, CH26, CH730-745 .... 0.026/0.176 mm (0.0010/0.0070 in.)

Top and Center Compression Ring End Gap
- New Bore - CH18, CH20, CH22 (624 cc) .... 0.25/0.45 mm (0.0098/0.0177 in.)
- New Bore - CH22 (674 cc) .... 0.18/0.46 mm (0.0071/0.0181 in.)
- New Bore - CH25, CH26, CH730-745 .... 0.25/0.56 mm (0.0100/0.0224 in.)
- Used Bore (Max.) - CH18, CH20, CH22 (624 cc) .... 0.77 mm (0.030 in.)
- Used Bore (Max.) - CH22/23 (674 cc) .... 0.80 mm (0.0315 in.)
- Used Bore (Max.) - CH25, CH26, CH730-745 .... 0.94 mm (0.037 in.)

Piston Thrust Face O.D.[2]
- New - CH18, CH20, CH22 (624 cc) .... 76.967/76.985 mm (3.0302/3.0309 in.)
- New - CH22/23 (674 cc) .... 79.963/79.979 mm (3.1481/3.1488 in.)
- New - CH25, CH26, CH730-745 .... 82.986 mm (3.3194 in.)
- Max. Wear Limit - CH18, CH20, CH22 (624 cc) .... 76.840 mm (3.0252 in.)
- Max. Wear Limit - CH22 (674 cc) .... 79.831 mm (3.1430 in.)
- Max. Wear Limit - CH25, CH26, CH730-745 .... 82.841 mm (3.3136 in.)

[2]Measure 6 mm (0.236 in.) above the bottom of the piston skirt at right angles to the piston pin.

Piston, Piston Rings, and Piston Pin cont.
Piston Thrust Face-to-Cylinder Bore[2] Running Clearance
New - CH18, CH20, CH22 (624 cc) .... 0.014/0.057 mm (0.0005/0.0022 in.)
New - CH22/23 (674 cc) .... 0.021/0.062 mm (0.0008/0.0024 in.)
New - CH25, CH26, CH730-745 .... 0.001/0.045 mm (0.039/0.0018 in.)

Speed Control Bracket
Fastener Torque .... 7.3-10.7 N·m (65-95 in. lb.)

Starter Assembly
Thru Bolt Torque
UTE/Johnson Electric, Eaton (Inertia Drive) .... 4.5-5.7 N·m (40-50 in. lb.)
Nippondenso (Solenoid Shift) .... 4.5-7.5 N·m (40-84 in. lb.)
Delco-Remy (Solenoid Shift) .... 5.6-9.0 N·m (49-79 in. lb.)

Mounting Screw Torque (All) .... 15.3 N·m (135 in. lb.)

Brush Holder Mounting Screw Torque
Delco-Remy Starter .... 2.5-3.3 N·m (22-29 in. lb.)

Solenoid (Starter)
Mounting Hardware Torque
Nippondenso Starter .... 6.0-9.0 N·m (53-79 in. lb.)
Delco-Remy Starter .... 4.0-6.0 N·m (35-53 in. lb.)
Nut, Positive (+) Brush Lead Torque
Nippondenso Starter .... 8.0-12.0 N·m (71-106 in. lb.)
Delco-Remy Starter .... 8.0-11.0 N·m (71-97 in. lb.)

Stator
Mounting Screw Torque .... 6.2 N·m (55 in. lb.)

Throttle/Choke Controls
Governor Control Lever Fastener Torque .... 9.9 N·m (88 in. lb.)

Valve Cover
Valve Cover Fastener Torque
Gasket Style Cover .... 3.4 N·m (30 in. lb.)
Black O-Ring Style Cover
w/Shoulder Screws .... 5.6 N·m (50 in. lb.)
w/Flange Screws and Spacers .... 9.9 N·m (88 in. lb.)
Brown O-Ring Style Cover w/Integral Metal Spacers .... 9.9 N·m (88 in. lb.)

Valves and Valve Lifters
Hydraulic Valve Lifter to Crankcase Running Clearance .... 0.0241/0.0501 mm (0.0009/0.0020 in.)

Intake Valve Stem-to-Valve Guide Running Clearance .... 0.038/0.076 mm (0.0015/0.0030 in.)

Exhaust Valve Stem-to-Valve Guide Running Clearance .... 0.050/0.088 mm (0.0020/0.0035 in.)

Intake Valve Guide I.D.
New .... 7.038/7.058 mm (0.2771/0.2779 in.)
Max. Wear Limit .... 7.135 mm (0.2809 in.)

Valves and Valve Lifters cont.

Exhaust Valve Guide I.D.
- New .... 7.038/7.058 mm (0.2771/0.2779 in.)
- Max. Wear Limit .... 7.159 mm (0.2819 in.)

Valve Guide Reamer Size
- Standard .... 7.048 mm (0.2775 in.)
- 0.25 mm O.S. .... 7.298 mm (0.2873 in.)

Intake Valve Minimum Lift .... 8.07 mm (0.3177 in.)

Exhaust Valve Minimum Lift .... 8.07 mm (0.3177 in.)

Nominal Valve Seat Angle .... 45°

General Torque Values

Metric Fastener Torque Recommendations for Standard Applications

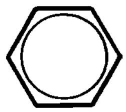
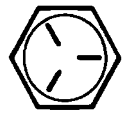
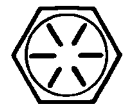
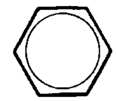
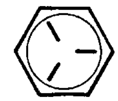
Tightening Torque: N·m (in. lb.) + or - 10%

Size	Property Class 4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)

Tightening Torque: N·m (ft. lb.) + or - 10%

Size	Property Class 4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (55)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

English Fastener Torque Recommendations for Standard Applications

Tightening Torque: N·m (in. lb.) + or - 20%				
Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel	 Grade 2	 Grade 5	 Grade 8	Grade 2 or 5 Fasteners Into Aluminum  
Size				
8-32	2.3 (20)	2.8 (25)	---------	2.3 (20)
10-24	3.6 (32)	4.5 (40)	---------	3.6 (32)
10-32	3.6 (32)	4.5 (40)	---------	---------
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	---------
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	---------	---------
3/8-16	29.4 (260)	---------	---------	---------
3/8-24	33.9 (300)	---------	---------	---------
Tightening Torque: N·m (ft. lb.) + or - 20%				
Size				
5/16-24	---------	----------	40.7 (30)	---------
3/8-16	---------	47.5 (35)	67.8 (50)	---------
3/8-24	---------	54.2 (40)	81.4 (60)	---------
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	---------
7/16-20	61.0 (45)	101.7 (75)	142.4 (105)	---------
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	---------
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	---------
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	---------
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	---------
5/8-11	149.2 (110)	244.1 (180)	352.6 (260)	---------
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	---------
3/4-10	199.3 (150)	332.2 (245)	474.6 (350)	---------
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	---------

Torque Conversions

N·m = in. lb. x 0.113
N·m = ft. lb. x 1.356
in. lb. = N·m x 8.85
ft. lb. = N·m x 0.737

Section 2
Special Tools

Certain quality tools are designed to help you perform specific disassembly, repair, and reassembly procedures. By using tools designed for the job, you can service engines easier, faster, and safer! In addition, you'll increase your service capabilities and customer satisfaction by decreasing engine downtime.

Kohler special tools are handled by SPX Corp., a division of Owatonna Tool Corp. (OTC). The tools are easy to purchase by contacting SPX/OTC by phone, fax, or mail.

Phone: 1-800-533-0492
International: 1-507-455-7223
8:00 am – 8:00 pm EST

Fax: 1-800-578-7375
1-586-578-7375
International: 1-507-455-7063

Mail: SPX Corp., OTC
28635 Mound Rd.
Warren, MI 48092-3499

Some special tools for this engine are:

Camshaft Endplay Plate	KO1031
Flywheel Strap Wrench	NU10357
Flywheel Puller Kit	NU3226
Rocker Arm Spanner Wrench	OEM6200
Valve Guide Reamer	KO1026
Water Manometer	KO1048
Cylinder Leakdown Tester	KO3219
Ignition System Tester	KO1046
Hydraulic Lifter Removal/Reinstallation Tool	KO1044
Starter Service Kit	KO3226
Starter Retaining Ring Tool	25 761 18-S
Vacuum Gauge	KO3223
Tachometer (Digital Inductive)	KO3216
Spark Advance Module (SAM) Tester	KO3222
Rectifier-Regulator Tester	KO3221

Electronic Fuel Injection (EFI) Service Tools

EFI Service Kit	KO3217
Gauge Assembly	KO3217-4
Pliers	KO3217-5
Circuit Tester	KO3217-6
Jumper Plug, Red (for metal cased ECU)	KO3217-7
Tee Valve Assembly	KO3217-8
Jumper Plug, Blue (for plastic cased ECU)	KO3217-9

Some of the specialty tools are shown and mentioned at various points in this manual. A complete catalog of available tools may be ordered under Kohler Part No. TP-2546. The tool price list is available under Kohler Part No. TP-2547.

Figure 2-1. Tool Catalog and Price List.

Special Tools You Can Make

Flywheel Holding Tool

Flywheel removal and reinstallation becomes a “snap” using a handy holding tool which can be made out of an old “junk” flywheel ring gear as shown in Figure 2-2. Using an abrasive cut-off wheel, cut out a six tooth segment of the ring gear as shown. Grind off any burrs or sharp edges. The segment can be used in place of a strap wrench. Invert the segment and place it between the ignition bosses on the crankcase so that the tool teeth engage the flywheel ring gear teeth. The bosses will “lock” the tool and flywheel in position for loosening, tightening or removing with a puller.

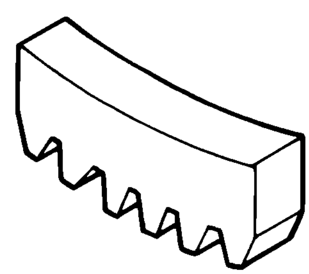


Figure 2-2. Flywheel Holding Tool.

Rocker Arm/Crankshaft Tool

If you don’t have a spanner wrench to lift the rocker arms or turn the crankshaft, you can make a tool for doing this out of an old junk connecting rod.

Find a used connecting rod from a 10 HP or larger engine. Remove and discard the rod cap. If it is a Posi-Lock rod, you will also need to remove the studs. If it is a Command rod, you will need to grind off the aligning steps, so the joint surface is flat. Find a 1 in. long capscrew with the correct thread size to match the threads in the connecting rod. Obtain a flat washer with the correct I.D. to slip on the capscrew and an O.D. of approximately 1 in. Kohler Part No. **12 468 05-S** can be used if you don’t have the right size on hand. Assemble the capscrew and washer to the joint surface of the rod, as shown in Figure 2-3.

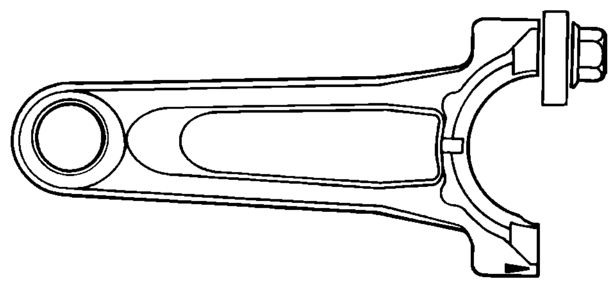


Figure 2-3. Rocker Arm/Crankshaft Tool.

Cylinder Leakdown Tester

A Cylinder Leakdown Tester (SPX Part No. KO3219 formerly Kohler 25 761 05-S) is a valuable alternate to a compression test on these engines. See Figure 2-4. By pressurizing the combustion chamber from an external air source, this tool can determine if valves or rings are leaking. Instructions for using this tester are found in Section 3 of this manual.

Figure 2-4. Cylinder Leakdown Tester.

RTV Silicone Sealant

RTV silicone sealant is used as a gasket between the crankcase and closure plate.

Only oxime-based, oil resistant RTV sealants, such as those listed below, are approved for use. Loctite® Nos. 5900 and 5910 are recommended for best sealing characteristics.

Loctite® Ultra Blue 587
Loctite® Ultra Copper
Loctite® Ultra Black 598
Loctite® 5900 (Heavy Body)
Loctite® 5910

NOTE: Always use **fresh** sealant. Using outdated sealant can result in leakage**.**

Loctite® 5900 is available in a 4 oz aerosol dispenser with replacement tips under Kohler Part No. **25 597 07-S**. See Figure 2-5.

Figure 2-5. Loctite® 5900 Aerosol Dispenser.

Camshaft Break-in Lubricant

Camshaft lubricant, Kohler Part No. **25 357 14-S** (Valspar ZZ613), should be used whenever a new camshaft and lifters are installed for proper break-in upon initial startup. Lubricant is included with each replacement camshaft and lifter, or may also be obtained separately in a 1/8 oz handy dispensing tube by the part number listed. See Figure 2-6.

Figure 2-6. Camshaft Break-in Lubricant.

Spline Drive Lubricant

Special spline drive crankshaft lubricant Kohler Part No. **25 357 12-S** is available in a 2.8 oz tube for use on all spline drive applications. This lubricant provides proper protection against wear-related damage. See Figure 2-7.

Figure 2-7. Crankshaft Spline Drive Lubricant.

Dielectric Grease

Dielectric grease is applied to the outside of the terminal connections on the SMART-SPARK™ ignition modules to prevent formation of a moisture path and arcing between the terminals. The chart below lists the approved dielectric greases.

Dielectric Grease

Vendor	Vendor No./ Description	Kohler Part No.
G.E./Novaguard	G661	25 357 11-S
Fel-Pro	Lubri-Sel	---

Section 3
Troubleshooting

Troubleshooting Guide

When troubles occur, be sure to check the simple causes which, at first, may seem too obvious to be considered. For example, a starting problem could be caused by an empty fuel tank.

Some general common causes of engine troubles are listed below. Use these to locate the causing factors. Refer to the specific section(s) within this service manual for more detailed information.

Engine Cranks But Will Not Start

1. Empty fuel tank.
2. Fuel shut-off valve closed.
3. Poor fuel, dirt or water in the fuel system.
4. Clogged fuel line.
5. Spark plug lead(s) disconnected.
6. Key switch or kill switch in “off” position.
7. Faulty spark plugs.
8. Faulty ignition module(s).
9. SMART-SPARK™ malfunction (applicable models).
10. Carburetor solenoid malfunction.
11. Diode in wiring harness failed in open circuit mode.
12. Vacuum fuel pump malfunction, or oil in vacuum hose.
13. Vacuum hose to fuel pump leaking/cracked.
14. Battery connected backwards.

Engine Starts But Does Not Keep Running

1. Restricted fuel tank cap vent.
2. Poor fuel, dirt or water in the fuel system.
3. Faulty or misadjusted choke or throttle controls.
4. Loose wires or connections that short the kill terminal of ignition module to ground.
5. Faulty cylinder head gasket.
6. Faulty carburetor.
7. Vacuum fuel pump malfunction, or oil in vacuum hose.
8. Leaking/cracked vacuum hose to fuel pump.
9. Intake system leak.
10. Diode in wiring harness failed in open circuit mode.

Engine Starts Hard

1. PTO drive is engaged.
2. Dirt or water in the fuel system.
3. Clogged fuel line.
4. Loose or faulty wires or connections.
5. Faulty or misadjusted choke or throttle controls.
6. Faulty spark plugs.
7. Low compression.
8. Weak spark.
9. Fuel pump malfunction causing lack of fuel.
10. Engine overheated-cooling/air circulation restricted.
11. Quality of fuel.
12. Flywheel key sheared.
13. Intake system leak.

Engine Will Not Crank

1. PTO drive is engaged.
2. Battery is discharged.
3. Safety interlock switch is engaged.
4. Loose or faulty wires or connections.
5. Faulty key switch or ignition switch.
6. Faulty electric starter or solenoid.
7. Seized internal engine components.

Engine Runs But Misses

1. Dirt or water in the fuel system.
2. Spark plug lead disconnected.
3. Poor quality of fuel.
4. Faulty spark plug(s).
5. Loose wires or connections that intermittently ground the ignition kill circuit.
6. Engine overheated.
7. Faulty ignition module or incorrect air gap.
8. Carburetor adjusted incorrectly.
9. SMART-SPARK™ malfunction (applicable models).

Engine Will Not Idle
1. Dirt or water in the fuel system.
2. Stale fuel and/or gum in carburetor.
3. Faulty spark plugs.
4. Fuel supply inadequate.
5. Idle speed adjusting screw improperly set.
6. Idle fuel adjusting needle improperly set (some models).
7. Low compression.
8. Restricted fuel tank cap vent.
9. Engine overheated-cooling system/air circulation problem.

Engine Overheats
1. Air intake/grass screen, cooling fins, or cooling shrouds clogged.
2. Excessive engine load.
3. Low crankcase oil level.
4. High crankcase oil level.
5. Faulty carburetor.
6. Lean fuel mixture.
7. SMART-SPARK™ malfunction (applicable models).

Engine Knocks
1. Excessive engine load.
2. Low crankcase oil level.
3. Old or improper fuel.
4. Internal wear or damage.
5. Hydraulic lifter malfunction.
6. Quality of fuel.
7. Incorrect grade of oil.

Engine Loses Power
1. Low crankcase oil level.
2. High crankcase oil level.
3. Dirty air cleaner element.
4. Dirt or water in the fuel system.
5. Excessive engine load.
6. Engine overheated.
7. Faulty spark plugs.
8. Low compression.
9. Exhaust restriction.
10. SMART-SPARK™ malfunction (applicable models).
11. Low battery.
12. Incorrect governor setting.

Engine Uses Excessive Amount of Oil
1. Incorrect oil viscosity/type.
2. Clogged or improperly assembled breather.
3. Breather reed broken.
4. Worn or broken piston rings.
5. Worn cylinder bore.
6. Worn valve stems/valve guides.
7. Crankcase overfilled.
8. Blown head gasket/overheated.

Oil Leaks from Oil Seals, Gaskets
1. Crankcase breather is clogged or inoperative.
2. Breather reed broken.
3. Loose or improperly torqued fasteners.
4. Piston blowby or leaky valves.
5. Restricted exhaust.

External Engine Inspection

Before cleaning or disassembling the engine, make a thorough inspection of its external appearance and condition. This inspection can give clues to what might be found inside the engine (and the cause) when it is disassembled.

- Check for buildup of dirt and debris on the crankcase, cooling fins, grass screen and other external surfaces. Dirt or debris on these areas are causes of higher operating temperatures and overheating.

- Check for obvious fuel and oil leaks, and damaged components. Excessive oil leakage can indicate a clogged or improperly-assembled breather, worn/damaged seals and gaskets, or loose or improperly-torqued fasteners.

- Check the air cleaner cover and base for damage or indications of improper fit and seal.

- Check the air cleaner element. Look for holes, tears, cracked or damaged sealing surfaces, or other damage that could allow unfiltered air into the engine. Also note if the element is dirty or clogged. These could indicate that the engine has been under serviced.

- Check the carburetor throat for dirt. Dirt in the throat is further indication that the air cleaner is not functioning properly.

- Check the oil level. Note if the oil level is within the operating range on the dipstick, or if it is low or overfilled.

- Check the condition of the oil. Drain the oil into a container - the oil should flow freely. Check for metal chips and other foreign particles.

  Sludge is a natural by-product of combustion; a small accumulation is normal. Excessive sludge formation could indicate overrich carburetion, weak ignition, overextended oil change interval or wrong weight or type of oil was used, to name a few.

  NOTE: It is good practice to drain oil at a location away from the workbench. Be sure to allow ample time for complete drainage.

Cleaning the Engine

After inspecting the external condition of the engine, clean the engine thoroughly before disassembling it. Also clean individual components as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, *follow the manufacturer's instructions and safety precautions carefully*.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Basic Engine Tests

Crankcase Vacuum Test

A partial vacuum should be present in the crankcase when the engine is operating at normal temperatures. Pressure in the crankcase (normally caused by a clogged or improperly assembled breather) can cause oil to be forced out at oil seals, gaskets, or other available spots.

Crankcase vacuum is best measured with either a water manometer (SPX Part No. KO1048, formerly Kohler Part No. 25 761 02-S) or a vacuum gauge (SPX Part No. KO3223, formerly Kohler Part No. 25 761 22-S). Complete instructions are provided in the kits.

To test the crankcase vacuum with the manometer:

1. Insert the stopper/hose into the oil fill hole. Leave the other tube of manometer open to atmosphere. Make sure the shut off clamp is closed.

2. Start the engine and run at no-load high speed (3200 to 3750 RPM).

3. Open the clamp and note the water level in the tube.

   The level in the engine side should be a minimum of **10.2 cm (4 in.)** above the level in the open side.

   If the level in the engine side is less than specified (low/no vacuum), or the level in the engine side is lower than the level in the open side (pressure), check for the conditions in the table on page 3.4.

4. Close the shut off clamp **before** stopping the engine.

To test the crankcase vacuum with the Vacuum/ Pressure Gauge Kit (SPX Part No. KO3223):

1. Remove the dipstick or oil fill plug/cap.

2. Install the adapter into the oil fill/dipstick tube opening, upside down over the end of a small diameter dipstick tube, or directly into engine if a tube is not used.

3. Push the barbed fitting on the gauge solidly into the hole in the adapter.

4. Start the engine and bring it up to operating speed (3200-3600 RPM).

5. Check the reading on the gauge. If the reading is to the **left** of "0" on the gauge, vacuum or negative pressure is indicated. If the reading is to the **right** of "0" on the gauge, positive pressure is present.

   Crankcase vacuum should be 4-10 (inches of water) If the reading is below specification, or if pressure is present, check the following table for possible causes and remedies.

No Crankcase Vacuum/Pressure in Crankcase

Possible Cause	Solution
1. Crankcase breather clogged or inoperative.	1. Disassemble breather, clean parts thoroughly, check sealing surfaces for flatness, reassemble, and recheck pressure.
2. Seals and/or gaskets leaking. Loose or improperly torqued fasteners.	2. Replace all worn or damaged seals and gaskets. Make sure all fasteners are tightened securely. Use appropriate torque values and sequences when necessary.
3. Piston blowby or leaky valves. (Confirm by inspecting components.)	3. Recondition piston, rings, cylinder bore, valves, and valve guides.
4. Restricted exhaust.	4. Repair/replace restricted muffler/exhaust system.

Compression Test
Some of these engines are equipped with an automatic compression release (ACR) mechanism. Because of the ACR mechanism, it is difficult to obtain an accurate compression reading. As an alternative, perform a cylinder leakdown test.

Cylinder Leakdown Test
A cylinder leakdown test can be a valuable alternative to a compression test. By pressurizing the combustion chamber from an external air source you can determine if the valves or rings are leaking, and how badly.

SPX Part No. KO3219 (formerly Kohler Part No. 25 761 05-S) is a relatively simple, inexpensive leakdown tester for small engines. The tester includes a quick disconnect for attaching the adapter hose, and a holding tool.

Leakdown Test Instructions

1. Run engine for 3-5 minutes to warm it up.

2. Remove spark plug(s) and air filter from engine.

3. Rotate the crankshaft until the piston (of cylinder being tested) is at top dead center of the compression stroke. Hold the engine in this position while testing. The holding tool supplied with the tester can be used if the PTO end of the crankshaft is accessible. Lock the holding tool onto the crankshaft. Install a 3/8" breaker bar into the hole/slot of the holding tool, so it is perpendicular to both the holding tool and crankshaft PTO. If the flywheel end is more accessible, use a breaker bar and socket on the flywheel nut/screw to hold it in position. An assistant may be needed to hold the breaker bar during testing. If the engine is mounted in a piece of equipment, it may be possible to hold it by clamping or wedging a driven component. Just be certain that the engine cannot rotate off of TDC in either direction.

4. Install the adapter into the spark plug hole, but do not attach it to the tester at this time.

5. Connect an air source of at least 50 psi to the tester.

6. Turn the regulator knob in the increase (clockwise) direction until the gauge needle is in the yellow “set” area at the low end of the scale.

7. Connect the tester quick-disconnect to the adapter hose while firmly holding the engine at TDC. Note the gauge reading and listen for escaping air at the carburetor intake, exhaust outlet, and crankcase breather.

8. Check your test results against the following table:

Leakdown Test Results

Air escaping from crankcase breather	Defective rings or worn cylinder.
Air escaping from exhaust system	Defective exhaust valve.
Air escaping from carburetor	Defective intake valve.
Gauge reading in "low" (green) zone	Piston rings and cylinder in good condition.
Gauge reading in "moderate" (yellow) zone	Engine is still usable, but there is some wear present. Customer should start planning for overhaul or replacement.
Gauge reading in "high" (red) zone	Rings and/or cylinder have considerable wear. Engine should be reconditioned or replaced.

Section 4
Air Cleaner and Air Intake System

Air Cleaners

General

Most engines are equipped with a replaceable, high-density paper air cleaner element, surrounded by an oiled foam precleaner, and housed under a flat outer cover. This is typically referred to as the standard air cleaner assembly. See Figures 4-1 and 4-4. Some engines utilize a heavy-duty style air cleaner as shown in Figure 4-12.

Figure 4-1. Standard Air Cleaner.

Standard Air Cleaner

Service

Check the air cleaner **daily or before starting the engine**. Check for and correct any buildup of dirt and debris, along with loose or damaged components.

NOTE: Operating the engine with loose or damaged air cleaner components could allow unfiltered air into the engine, causing premature wear and failure.

Figure 4-2. Removing Latch Style Cover.

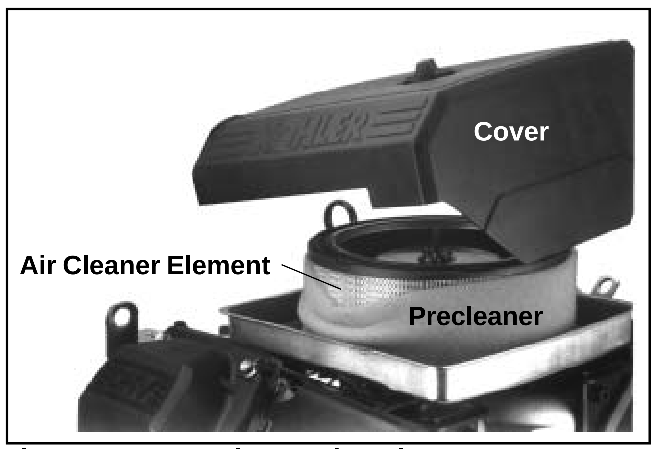


Figure 4-3. Removing Knob Style Cover.

Precleaner Service

If so equipped, wash and reoil the precleaner every **25 hours** of operation (more often under extremely dusty or dirty conditions).

To service the precleaner, perform the following steps:

1. Unhook the latches or loosen the retaining knob, and remove the cover.

2. Remove the foam precleaner from the paper air cleaner element.

3. Wash the precleaner in warm water with detergent. Rinse the precleaner thoroughly until all traces of detergent are eliminated. Squeeze out excess water (do not wring). Allow the precleaner to air dry.

4. Saturate the precleaner with new engine oil. Squeeze out all excess oil.

5. Reinstall the precleaner over the paper air cleaner element.

6. Reinstall the air cleaner cover. Secure the cover with the two latches or the retaining knob.

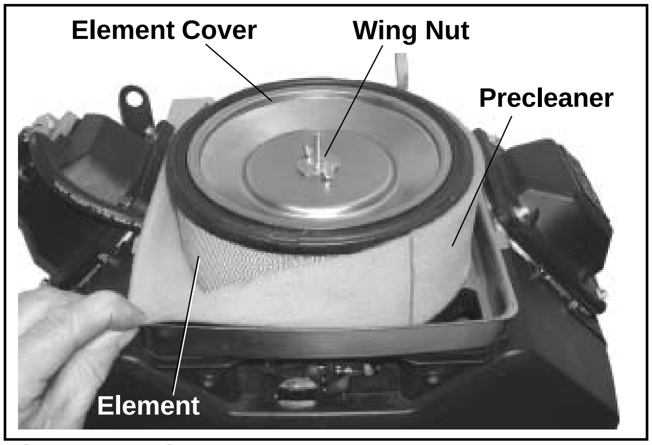


Figure 4-4. Air Cleaner Components.

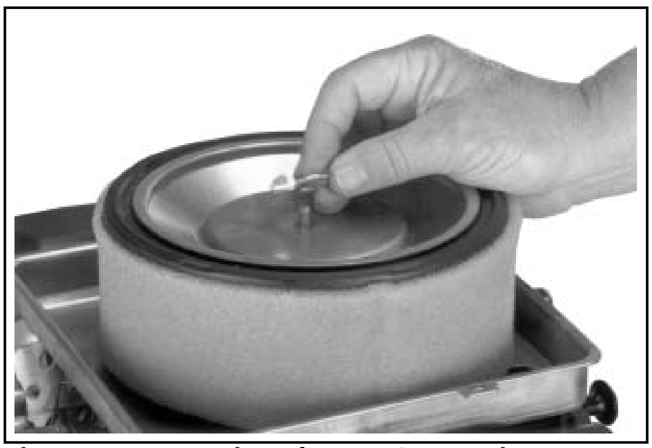


Figure 4-5. Removing Element Cover Wing Nut.

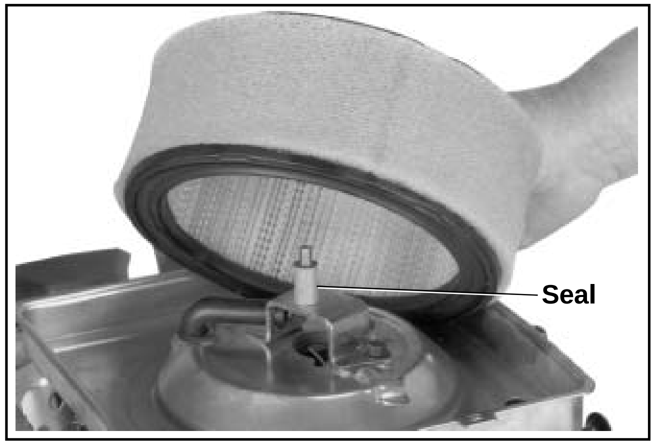


Figure 4-6. Removing Elements.

Figure 4-7. Removing Rubber Seal from Bracket.

Paper Element Service (Standard Type)
Every **100 hours** of operation (more often under extremely dusty or dirty conditions), replace the paper element. Follow these steps:

1. Unhook the latches or loosen the retaining knob, and remove the cover.

2. Remove the wing nut, element cover, and paper element with precleaner (if so equipped).

3. Remove the precleaner (if so equipped) from the paper element. Service the precleaner as described in "Precleaner Service".

4. **Do not wash the paper element or use pressurized air**, as this will damage the element. Replace a dirty, bent, or damaged element with a genuine Kohler element. Handle new elements carefully; do not use if the sealing surfaces are bent or damaged.

5. Check the seal for any damage or deterioration. Replace as necessary. See Figure 4-7.

6. Reinstall the seal, paper element, precleaner, element cover, and wing nut.

7. Reinstall the air cleaner cover and secure with the latches or the retaining knob.

NOTE: Make sure the correct depth air cleaner element and rubber seal are used for the engine spec involved. Some engines use a deeper or extra capacity air cleaner and a longer rubber seal.

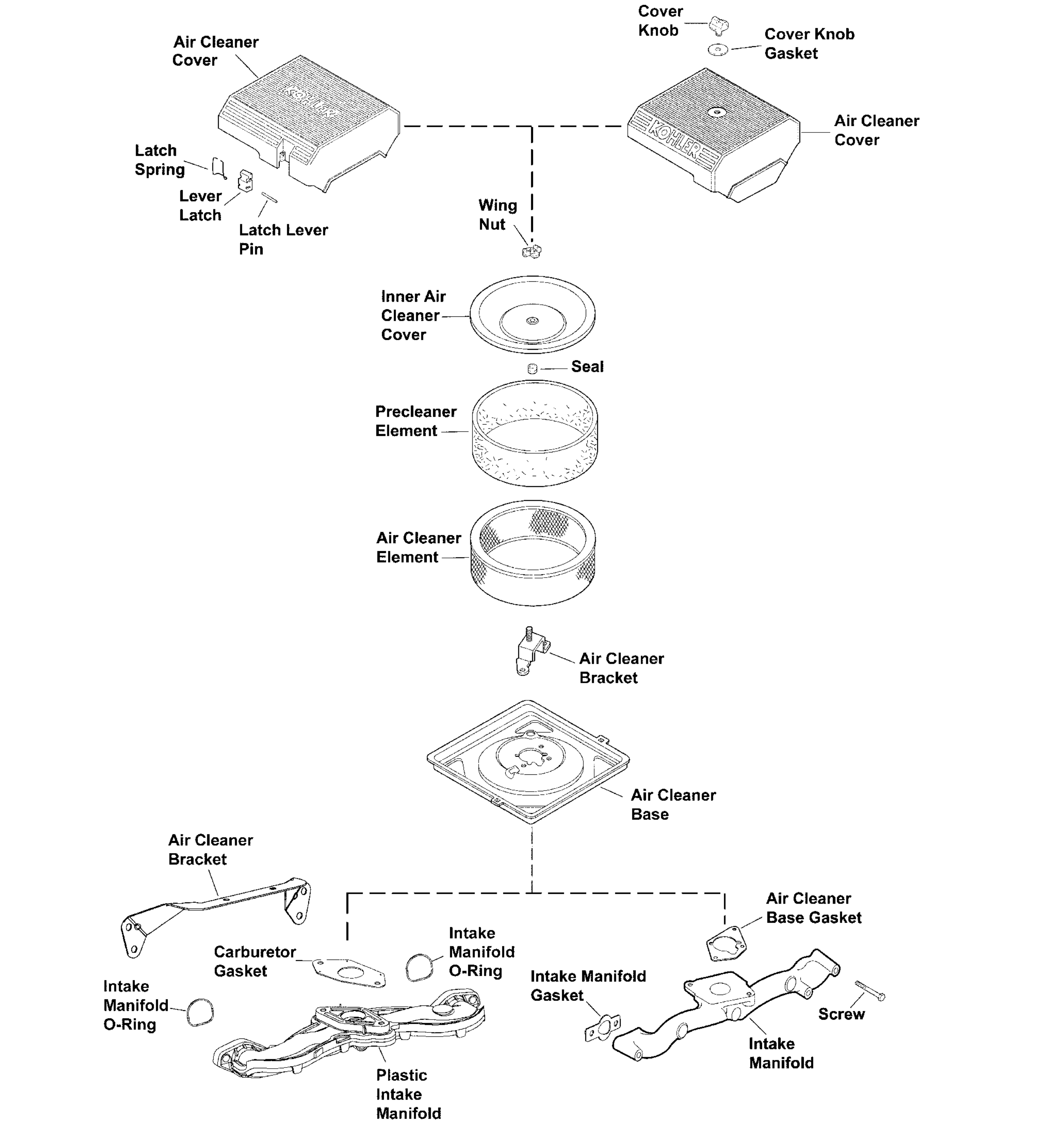


Figure 4-8. Exploded View of Standard Air Intake System Components.

Figure 4-9. Bracket Retaining Screw.

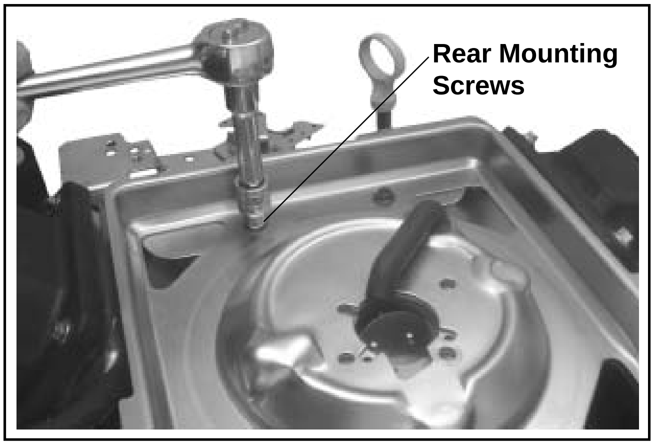


Figure 4-10. Rear Mounting Screws (Used with Plastic Intake Manifold).

Figure 4-11. Breather Tube.

Air Cleaner Components
Whenever the air cleaner cover is removed, or the paper element or precleaner are serviced, check the following:

Air Cleaner Element Cover and Seal - Make sure element cover is not bent or damaged. Make sure the wing nut and seal are in place to ensure the element is sealed against leakage.

Air Cleaner Base - Make sure the base is secured tightly to the carburetor and not cracked or damaged.

Breather Tube - Make sure the tube is attached to both the air cleaner base and the breather cover.

NOTE: Damaged, worn or loose air cleaner components can allow unfiltered air into the engine causing premature wear and failure. Tighten or replace all loose or damaged components.

Complete Disassembly and Reassembly - Standard Type

If the base plate on the standard type has to be removed, proceed as follows:

1. Remove air cleaner components as described earlier.
2. Remove the hex. flange screws securing the bracket and base. See Figures 4-9 and 4-10. Remove the bracket.
3. Pinch the sealing collar on the breather hose and push it down through the hole in the air cleaner base. Carefully feed the upper section of the breather tube down through the base. See Figure 4-11.
4. Remove the base and gasket.
5. Reverse the procedure to reinstall new or serviced components. Torque screws to **9.9 N·m (88 in. lb.)**.

Heavy-Duty Air Cleaner

General
The heavy-duty air cleaner consists of a cylindrical housing, typically mounted to a bracket off the upper valve cover screws, and connected with a formed rubber hose to an adapter on the carburetor or throttle body/intake manifold (EFI units). The air cleaner housing contains a paper element and inner element, designed for longer service intervals. The system is CARB/EPA certified and the components should not be altered or modified in any way.

Figure 4-12. Heavy-Duty Air Cleaner.

To Service
Every **250 hours** of operation (more often under extremely dusty or dirty conditions), replace the paper element and check the inner element. Follow these steps.

1. Unhook the two retaining clips and remove the end cap from the air cleaner housing.

2. Pull the air cleaner element out of the housing. See Figure 4-13.

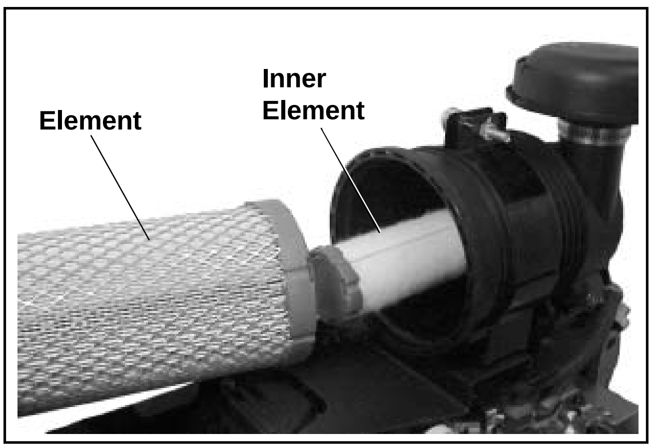


Figure 4-13. Removing Elements.

3. After the element is removed, check the condition of the inner element. It should be replaced whenever it appears dirty, typically every other time the main element is replaced. Clean the area around the base of the inner element before removing it, so dirt does not get into the engine.

4. **Do not** wash the paper element and inner element or use compressed air, this will damage the elements. Replace dirty, bent or damaged elements with new genuine Kohler elements as required. Handle the new elements carefully; do not use if the sealing surfaces are bent or damaged.

5. Check all parts for wear, cracks, or damage. Replace any damaged components.

6. Install the new inner element, followed by the outer element. Slide each fully into place in the air cleaner housing.

7. Reinstall the end cap so the dust ejector valve is down, and secure with the two retaining clips. See Figure 4-12.

Removal
1. Remove the upper valve cover screws on each side, securing the main bracket, and loosen the hose clamp on the adapter inlet, or remove the adapter mounting screws.

2. Lift the entire air cleaner assembly off the engine. Disassemble or service as required.

Installation
1. Install the main mounting bracket with the center section up and the cutout around the carburetor, aligning the mounting holes with the four upper valve cover holes.

2. Install and torque the four valve cover mounting screws to **7.9 N·m (70 in. lb.)**.

3. Reconnect the hose to the adapter and tighten the clamp, or install a new adapter gasket (if the adapter was separated from the carburetor), and torque the mounting fasteners to **7.3 N·m (65 in. lb.)**.

   NOTE: Adapter configurations may vary depending on engine and application involved. Two adapters are shown in Figure 4-14.

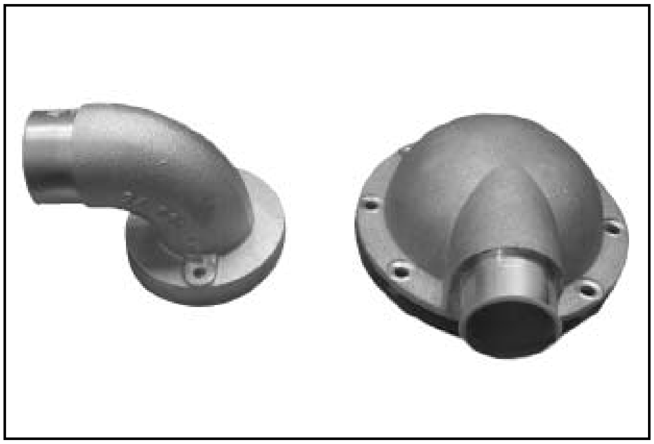


Figure 4-14. Adapters for Heavy-Duty Air Cleaners.

Figure 4-15. Cleanout Kit Installed on Blower Housing.

Air Intake/Cooling System

To ensure proper cooling, make sure the grass screen, cooling fan fins, and external surfaces of the engine are kept clean **at all times**.

Every **100 hours** of operation (more often under extremely dusty or dirty conditions), remove the blower housing and other cooling shrouds.*Clean the cooling fins and external surfaces as necessary. Make sure the cooling shrouds are reinstalled.

*Cleanout kits, Kohler Part No. **25 755 20-S** (black) or **25 755 21-S** (gold), are recommended to aid inspection and cleanout of the cooling fins. See Figure 4-15.

NOTE: Operating the engine with a blocked grass screen, dirty or plugged cooling fins, and/or cooling shrouds removed, will cause engine damage due to overheating.

Section 5
Fuel System and Governor

Description
The Command horizontal twins use three different types of fuel systems; carbureted, electronic fuel injection (EFI), or gaseous. Gaseous fuel systems can be either liquefied petroleum gas (LPG or LP) or natural gas (NG). Some dual-fuel engines have a combination system, which allows the operator to select either gasoline or LP.

This section covers the standard carbureted fuel systems. The gaseous systems are covered in subsection 5A and the EFI systems are covered in subsection 5B. The governor systems used are covered at the end of this section.

WARNING: Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Fuel System Components
The typical carbureted fuel system and related components include the following:

- Fuel Tank
- Fuel Lines
- In-line Fuel Filter
- Fuel Pump
- Carburetor

Operation
The fuel from the tank is moved through the in-line filter and fuel lines by the fuel pump. On engines not equipped with a fuel pump, the fuel tank outlet is located above the carburetor inlet allowing gravity to feed fuel to the carburetor.

Fuel then enters the carburetor float bowl and is drawn into the carburetor body. There, the fuel is mixed with air. This fuel-air mixture is then burned in the engine combustion chamber.

Fuel Recommendations

General Recommendations
Purchase gasoline in small quantities and store in clean, approved containers. A container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps eliminate spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system and to ensure easy starting.
- Do not add oil to the gasoline.
- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type
For best results, use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research fuel rating method, it should be 90 octane minimum.

Unleaded gasoline is recommended as it leaves less combustion chamber deposits and reduces harmful exhaust emissions. Leaded gasoline is not recommended and ***must not*** be used on EFI engines, or on other models where exhaust emissions are regulated.

Gasoline/Alcohol blends
Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends
Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler engines. Other gasoline/ether blends are not approved.

Fuel Filter
Most engines are equipped with an in-line filter. Visually inspect the filter periodically and replace when dirty with a genuine Kohler filter.

Fuel System Tests
When the engine starts hard, or turns over but will not start, it is possible that the problem is in the fuel system. To find out if the fuel system is causing the problem, perform the following tests.

Troubleshooting – Fuel System Related Causes

Test	Conclusion
1. Check the following: a. Make sure the fuel tank contains clean, fresh, proper fuel. b. Make sure the vent in fuel tank is open. c. Make sure the fuel valve is open. d. Make sure vacuum and fuel lines to fuel pump are secured and in good condition.	
2. Check for fuel in the combustion chamber. a. Disconnect and ground spark plug leads. b. Close the choke on the carburetor. c. Crank the engine several times. d. Remove the spark plug and check for fuel at the tip.	2. If there **is** fuel at the tip of the spark plug, fuel is reaching the combustion chamber. If there is **no** fuel at the tip of the spark plug, check for fuel flow from the fuel tank (Test 3).
3. Check for fuel flow from the tank to the fuel pump. a. Remove the fuel line from the inlet fitting of fuel pump. b. Hold the line below the bottom of the tank. Open the shut-off valve (if so equipped) and observe flow.	3. If fuel **does** flow from the line, check for faulty fuel pump (Test 4). If fuel **does not** flow from the line, check the fuel tank vent, fuel pickup screen, in-line filter, shut-off valve, and fuel line. Correct any observed problem and reconnect the line.
4. Check the operation of fuel pump. a. Remove the fuel line from the inlet fitting of carburetor. b. Crank the engine several times and observe flow.	4. If fuel **does** flow from the line, check for faulty carburetor. (Refer to the "Carburetor" portions of this section.) If fuel **does not** flow from the line, check for a clogged fuel line. If the fuel line is unobstructed, check for overfilled crankcase and/or oil in pulse line. If none of the checks reveal the cause of the problem, replace the pump.

Fuel Pump

General

These engines are equipped with either a pulse or mechanical fuel pump. See Figures 5-1 and 5-2. The pumping action is created by either the oscillation of positive and negative pressures within the crankcase through a hose, or by direct lever/pump actuation off rocker arm movement. The pumping action causes the diaphragm on the inside of the pump to pull fuel in on its downward stroke and to push it into the carburetor on its upward stroke. Internal check valves prevent fuel from going backward through the pump.

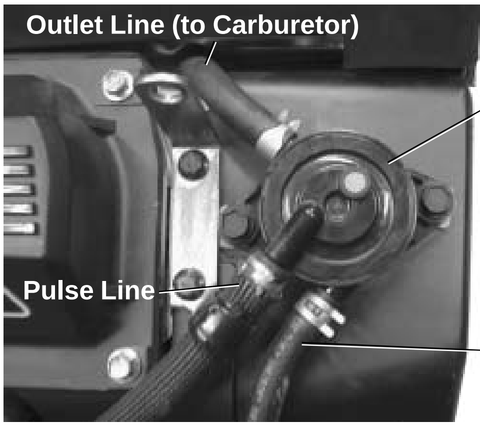


Figure 5-1. Pulse Style Fuel Pump.

Performance

Minimum fuel delivery rate must be 7.5 L/hr. (2 gal./hr.) with a pressure at 0.3 psi and a fuel lift of 18 in. from carburetor inlet. A 1.3 L/hr. (0.34 gal./hr.) fuel rate must be maintained at 5 Hz.

Fuel Pump - Replacement

Replacing the Pulse Fuel Pump

Replacement pumps are available through your source of supply. To replace the pulse pump follow these steps.

1. Disconnect the fuel lines from the inlet and outlet fittings.

2. Remove the hex. flange screws securing the fuel pump.

3. Remove the pulse line that connects the pump to the crankcase or valve cover.

   NOTE: On most models, the pulse line is connected to a fitting on the crankcase, while on early models, it is connected to the valve cover.

4. Install the new fuel pump using the hex. flange screws. Torque the hex. flange screws to **2.3 N·m (20 in. lb.)**.

   NOTE: Make sure the orientation of the new pump is consistent with the removed pump. Internal damage may occur if installed incorrectly.

5. Connect the pulse line to the pulse fitting.

6. Connect the fuel lines to the inlet and outlet fittings.

5

Replacing the Mechanical Pump

The mechanical pump is an integral part of the valve cover assembly and not serviced separately. See Figure 5-2.

1. Disconnect the fuel lines from the inlet and outlet fittings.

2. Follow the procedure for replacing the valve cover (Sections 9 and 11).

3. Reconnect the fuel lines to the inlet and outlet fittings.

Figure 5-2. Mechanical Fuel Pump.

Carburetor

General

These engines are equipped with fixed main jet carburetors manufactured by Keihin to Kohler specifications. Most have automatic chokes and fuel shut-off solenoids. Keihin carburetors with accelerator pump features are standard on many models, and are furnished as an option on other CH applications where improved performance is required during periods of rapid acceleration. Both types are almost identical except for the accelerator pump parts shown in the inset in Figure 5-8. Most information in the following pertains to both type carburetors, with differences pointed out or shown wherever pertinent.

WARNING: Explosive Fuel
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Troubleshooting - Carburetor Related Causes

Condition	Possible Cause/Probable Remedy
1. Engine starts hard, runs roughly or stalls at idle speed.	1. Low idle fuel mixture (some models)/speed improperly adjusted. Adjust the low idle speed tab, then adjust the low idle fuel needle.
2. Engine runs rich (indicated by black, sooty exhaust smoke, misfiring, loss of speed and power, governor hunting, or excessive throttle opening).	2a. Clogged air cleaner. Clean or replace. b. Choke partially closed during operation. Check the choke lever/ linkage to ensure choke is operating properly. c. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle (some models). d. Float level is set too high. Separate carburetor air horn from carburetor body, adjust float according to steps 4 and 5 on page 5.7. e. Dirt under the fuel inlet needle. Remove needle; clean needle and seat and blow with compressed air. f. Bowl vent or air bleeds plugged. Remove low idle fuel adjusting needle. Clean vent, ports, and air bleeds. Blow out all passages with compressed air. g. Leaky, cracked or damaged float. Submerge float to check for leaks.
3. Engine runs lean (indicated by misfiring, loss of speed and power, governor hunting or excessive throttle opening).	3a. Low idle fuel mixture is improperly adjusted. Adjust low idle fuel needle (some models). b. Float level is set too low. Separate carburetor air horn from carburetor body, adjust float according to steps 4 and 5 on page 5.7. c. Idle holes plugged; dirt in fuel delivery channels. Remove low idle fuel adjusting needle. Clean main fuel jet and all passages; blow out with compressed air.
4. Fuel leaks from carburetor.	4a. Float level set too high. See Remedy 2d. b. Dirt under fuel inlet needle. See Remedy 2e. c. Bowl vents plugged. Blow out with compressed air. d. Carburetor bowl gasket leaks. Replace gasket.

Troubleshooting Checklist
When the engine starts hard, runs roughly or stalls at low idle speed, check the following areas before adjusting or disassembling the carburetor.

- Make sure the fuel tank is filled with clean, fresh gasoline.
- Make sure the fuel tank cap vent is not blocked and that it is operating properly.
- Make sure fuel is reaching the carburetor. This includes checking the fuel shut-off valve, fuel tank filter screen, in-line fuel filter, fuel lines and fuel pump for restrictions or faulty components as necessary.
- Make sure the air cleaner base and carburetor are securely fastened to the engine using gaskets in good condition.
- Make sure the air cleaner element (including precleaner if equipped) is clean and all air cleaner components are fastened securely.
- Make sure the ignition system, governor system, exhaust system, and throttle and choke controls are operating properly.

If the engine is hard-starting, runs roughly, or stalls at low idle speed, it may be necessary to adjust or service the carburetor.

High Altitude Operation
When operating the engine at altitudes of 1500 m (5000 ft.) and above, the fuel mixture tends to get over-rich. This can cause conditions such as black, sooty exhaust smoke, misfiring, loss of speed and power, poor fuel economy, and poor or slow governor response.

To compensate for the effects of high altitude, special high altitude jet kits are available. The kits include a new main jet, slow jet (where applicable), necessary gaskets and O-Rings. Refer to the parts manual for the correct kit number.

Fuel Shut-off Solenoid
Most carburetors are equipped with a fuel shut-off solenoid. The solenoid is attached in place of the fixed main jet screw on the flywheel side of the carburetor. See Figure 5-3. The solenoid has a spring-loaded pin that retracts when 12 volts is applied to the lead, allowing fuel flow through the main jet. When current is removed the pin extends blocking the main fuel jet and preventing fuel from entering the carburetor.

Figure 5-3. Fuel Shut-off Solenoid.

Below is a simple test, made with the engine off, that can determine if the solenoid is functioning properly:

1. Shut off fuel and remove the solenoid from the carburetor. When the solenoid is loosened and removed, gas will leak out of the carburetor. Have a container ready to catch the fuel.
2. Wipe the tip of the solenoid with a shop towel or blow it off with compressed air, to remove any remaining fuel. Take the solenoid to a location with good ventilation and no fuel vapors present. You will also need a 12 volt power source that can be switched on and off.
3. Be sure the power source is switched “off”. Connect the positive power source lead to the red lead of the solenoid. Connect the negative power source lead to the solenoid bracket.
4. Turn the power source “on” and observe the pin in the center of the solenoid. The pin should retract with the power “on” and return to its original position with the power off. Test several times to verify operation.

5

Carburetor Adjustments

General
In compliance with government emission standards, the carburetor is calibrated to deliver the correct air-to-fuel mixture to the engine under all operating conditions. The high-speed mixture is preset and cannot be adjusted. Pre-compliance carburetors contain a low idle fuel adjusting needle, on "certified" compliance carburetors, both the low and high speed mixture circuits are pre-established and cannot be adjusted. The low idle speed (RPM) is the only adjustment available. See Figures 5-4 and 5-5.

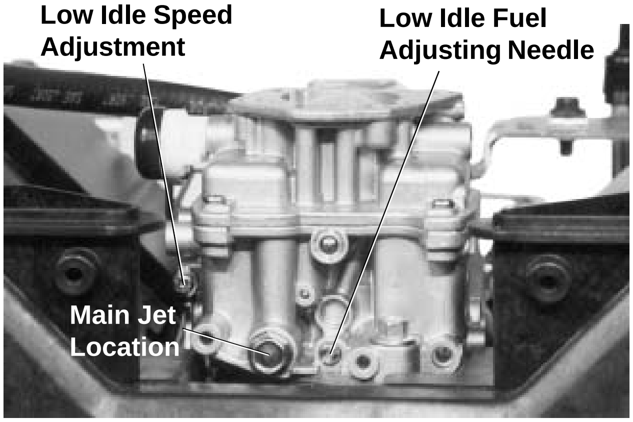


Figure 5-4. Pre-Compliance Carburetor with Low Idle Adjustment.

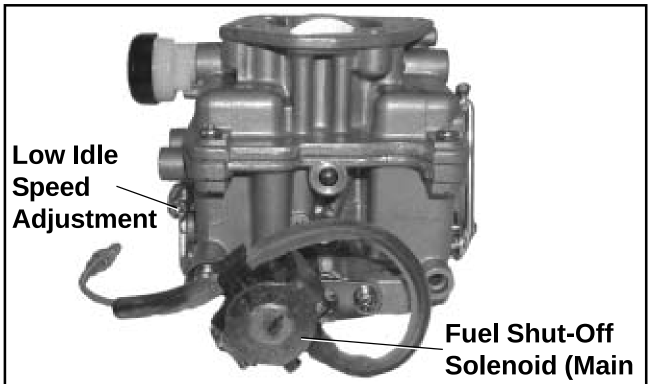


Figure 5-5. "Certified" Compliance Carburetor.

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

Adjusting Low Idle Speed and Fuel (Some Models)
To adjust the carburetor idle speed, see Figure 5-4 and follow these steps.

1. With the engine **stopped**, turn the low idle fuel adjusting needle in **clockwise** until it bottoms **lightly**.

   NOTE: The tip of the idle fuel adjusting needle is tapered to critical dimensions. Damage to the needle and the seat in the carburetor body will result if the needle is forced.

2. Now turn the adjusting needle out **counterclockwise** 1-1/2 turns.

3. Start the engine and run at half throttle for 5 to 10 minutes to warm up. The engine must be warm before making final settings. Check that the throttle and choke plates can fully open.

   NOTE: The carburetor has a self-relieving choke. Choke plate and shaft assembly is spring loaded. Check to make sure plate moves freely and is not binding and affecting idle fuel delivery.

4. Place the throttle control into the "idle" or "slow" position. Turn the low idle speed adjusting screw in or out to obtain a low idle speed of 1200 RPM (± 75 RPM). Check the speed using a tachometer.

   NOTE: The actual low idle speed depends on the application. Refer to the equipment manufacturer's recommendations. The low idle speed for basic engines is 1200 RPM. To ensure best results when setting the low idle fuel needle, the low idle speed should be 1200 RPM (± 75 RPM).

5. Turn the low idle fuel adjusting needle in (slowly) until engine speed decreases and then back out approximately 3/4 turn to obtain the best low speed performance.

6. Recheck the idle speed using a tachometer and readjust the speed as necessary.

Float
It is not necessary to remove the carburetor from the engine to check and adjust the float.

1. Remove the air cleaner and breather hose. Refer to Section 9 – "Disassembly".

2. Disconnect the fuel line from the carburetor. See Figure 5-6.

3. Clean dirt and debris from exterior of carburetor.

4. Remove the four screws holding the two carburetor halves together. Carefully lift the upper body off the carburetor body and disconnect choke linkage.

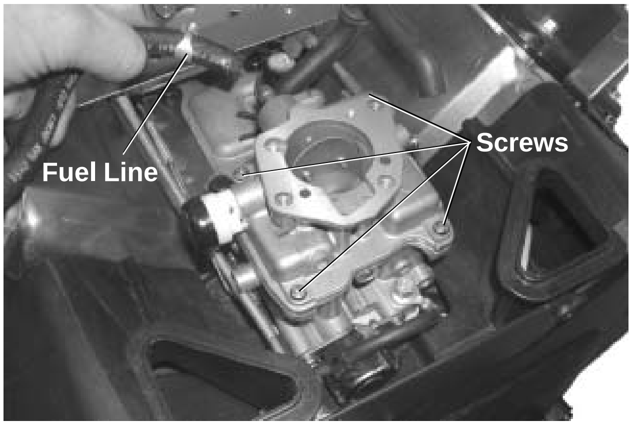


Figure 5-6. Carburetor Detail.

5. Hold the carburetor upper body so that the float assembly hangs vertically and rests lightly against the fuel inlet needle. The fuel inlet needle should be fully seated, but the needle tip should not be depressed. See Figure 5-7.

   NOTE: The fuel inlet needle tip is spring loaded. Make sure the float assembly rests against the fuel inlet needle without depressing the tip.

6. The correct float height adjustment is 22 mm (0.86 in.), measured from the float bottom to the air horn casting. Adjust the float height by carefully bending the tab.

   NOTE: Be sure to measure from the casting surface, not the rubber gasket surface.

7. If proper float height adjustment cannot be achieved, check to see if the fuel inlet needle is dirty, obstructed or worn. Remove the brass screw and float assembly to remove the fuel inlet needle.

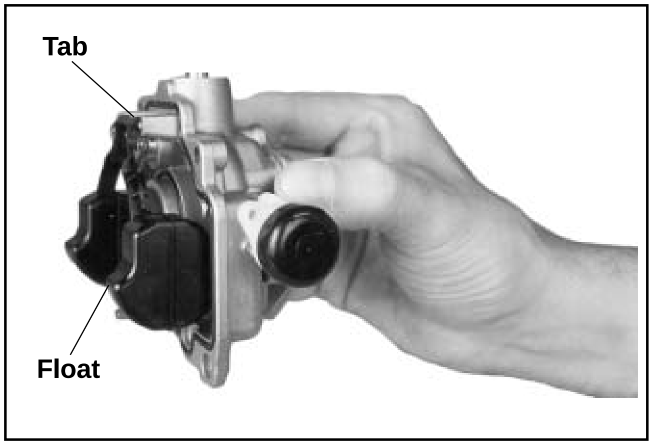


Figure 5-7. Carburetor Float Adjustment.

8. Once the proper float height is obtained, carefully lower the carburetor air horn assembly onto the carburetor body, connecting the choke linkage. Install the four screws. Torque the screws to **1.7 N·m (15 in. lb.)**. See Figure 5-6.

9. Connect the fuel line.

10. Install the breather hose and air cleaner assembly, following the steps in Section 11 – “Reassembly”.

Disassembly

Disassemble the carburetor using the following steps. See Figure 5-8.

1. Remove the air cleaner, breather hose and carburetor. Refer to Section 9 – “Disassembly”.

2. Remove the four screws and carefully separate the air horn assembly from the carburetor body.

3. Loosen the screw securing the float assembly to the air horn and remove the float, float shaft and fuel inlet needle.

4. Remove the slow jet from the carburetor body.

   NOTE: The main jet is a fixed jet and can be removed if required. Fixed jets for high altitude are available.

5. Remove the black cap on the end of the choke shaft only if it is necessary to inspect and clean the shaft spring.

6. Remove the low idle speed adjusting screw and spring from the carburetor body.

7. In order to clean the ''off-idle'' vent ports and bowl vent thoroughly, use a good carburetor solvent (like Gumout™). Blow clean compressed air through the idle adjusting needle hole. Be careful to use a suitable shop rag to prevent debris from hitting someone.

8. Remove the preformed rubber gasket only if it is to be replaced. If it is removed for any reason, replace it.

Inspection/Repair

Carefully inspect all components and replace those that are worn or damaged.

- Inspect the carburetor body for cracks, holes and other wear or damage.

- Inspect the float for cracks, holes, and missing or damaged float tabs. Check the float hinge and shaft for wear or damage.

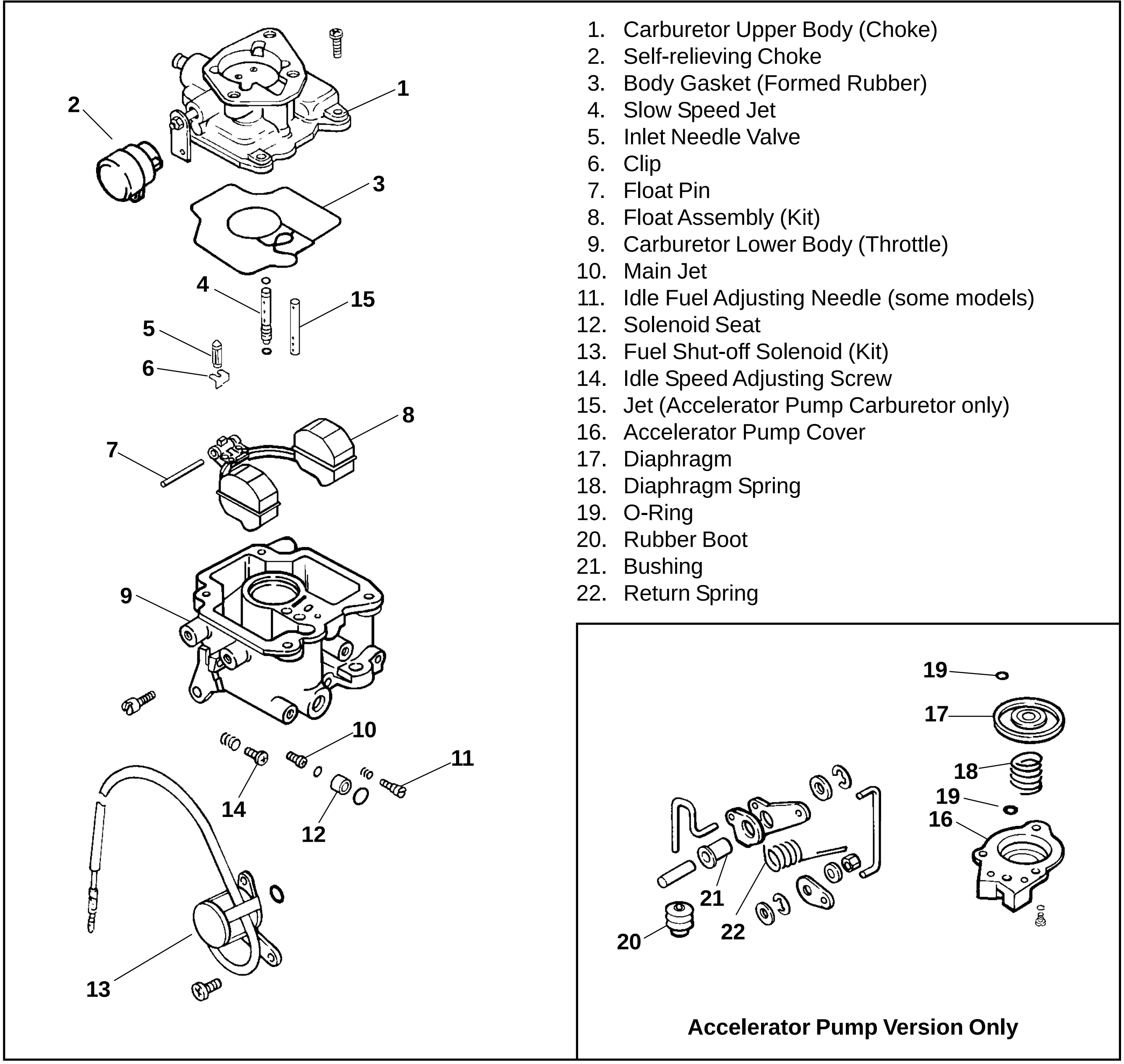
- Inspect the fuel inlet needle and seat for wear or damage.

- Inspect the tip of the low idle fuel adjusting needle for wear or grooves.

- The choke plate is spring loaded. Check to make sure it moves freely on the shaft.

  NOTE: The choke and throttle plate assemblies are staked and matched to the shafts at the factory. They are not serviceable items.

Always use new gaskets when servicing or reinstalling carburetors. Repair kits are available which include new gaskets and other components. These kits are described on the next page.



1. Carburetor Upper Body (Choke)
2. Self-relieving Choke
3. Body Gasket (Formed Rubber)
4. Slow Speed Jet
5. Inlet Needle Valve
6. Clip
7. Float Pin
8. Float Assembly (Kit)
9. Carburetor Lower Body (Throttle)
10. Main Jet
11. Idle Fuel Adjusting Needle (some models)
12. Solenoid Seat
13. Fuel Shut-off Solenoid (Kit)
14. Idle Speed Adjusting Screw
15. Jet (Accelerator Pump Carburetor only)
16. Accelerator Pump Cover
17. Diaphragm
18. Diaphragm Spring
19. O-Ring
20. Rubber Boot
21. Bushing
22. Return Spring

Figure 5-8. Carburetor – Exploded View.

Components such as the throttle and choke shaft assemblies, throttle plate, choke plate, low idle fuel needle, and others, are available separately.

Always refer to the Parts Manual for the engine being serviced, to ensure the correct repair kits and replacement parts are ordered. Service/repair kits available for the carburetor and affiliated components are:

Carburetor Repair Kit
Float Kit
High Altitude Kit (1525-3048 m/5,000-10,000 ft)
High Altitude Kit (over 3048 m/10,000 ft)
Solenoid Assembly Kit
Accelerator Pump Seal and Bushing Kit
Accelerator Pump Diaphragm Kit
Choke Repair Kit

Reassembly

Reassemble the carburetor using the following steps. See Figure 5-9.

1. Assemble the fuel inlet needle to the float tab. Install the float, float shaft and inlet needle to the air horn. Tighten the screw. Check float height using the procedure found previously in the ''Adjustments'' subsection.

2. Install the slow jet with the stepped end toward the bottom of the carburetor. Make sure jet is fully seated.

3. Install the low idle adjusting needle and spring.

4. Assemble the upper body onto the lower carburetor body using the four screws. Torque the screws to **1.7 N·m (15 in. lb.)**.

5. Install the carburetor on the engine following the procedures in Section 11 – ''Reassembly.''

Governor

General

The governor is designed to hold the engine speed constant under changing load conditions. Most engines are equipped with a centrifugal flyweight mechanical governor. Some engines utilize an optional electronic governor, which is shown and covered on page 5.12 and 5.13. The governor gear/flyweight mechanism of the mechanical governor is mounted inside the crankcase and is driven off the gear on the camshaft. This governor design works as follows:

- Centrifugal force acting on the rotating governor gear assembly causes the flyweights to move outward as speed increases. Governor spring tension moves them inward as speed decreases.

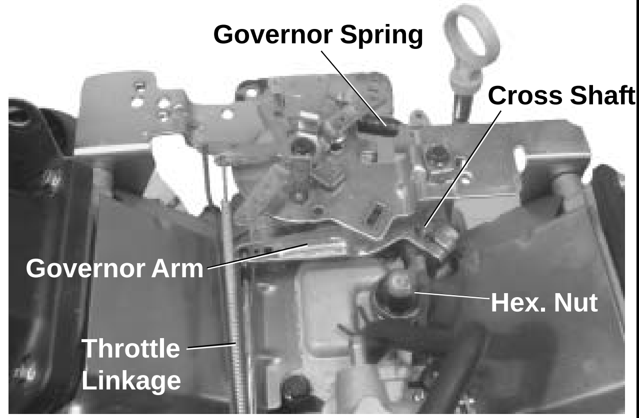


Figure 5-9. Governor Linkage.

- As the flyweights move outward, they cause the regulating pin to move outward.

- The regulating pin contacts the tab on the cross shaft causing the shaft to rotate.

- One end of the cross shaft protrudes through the crankcase. The rotating action of the cross shaft is transmitted to the throttle lever of the carburetor through the external throttle linkage. See Figure 5-9.

- When the engine is at rest, and the throttle is in the "fast" position, the tension of the governor spring holds the throttle plate open. When the engine is operating, the governor gear assembly is rotating. The force applied by the regulating pin against the cross shaft tends to close the throttle plate. The governor spring tension and the force applied by the regulating pin balance each other during operation, to maintain engine speed.

- When load is applied and the engine speed and governor gear speed decreases, the governor spring tension moves the governor arm to open the throttle plate wider. This allows more fuel into the engine, increasing the engine speed. As the speed reaches the governed setting, the governor spring tension and the force applied by the regulating pin will again offset each other to hold a steady engine speed.

Adjustments

NOTE: Do not tamper with the governor setting. Overspeed is hazardous and could cause personal injury.

General
The governed speed setting is determined by the position of the throttle control. It can be variable or constant, depending on the engine application.

Initial Adjustment
NOTE: EFI engines require a special initial adjustment procedure, which is covered in subsection 5B. Refer to “Initial Governor Adjustment” in that section for setting the governor on EFI-equipped engines.

Procedure – Carburetor Equipped Engines
Make this adjustment whenever the governor arm is loosened or removed from the cross shaft. See Figure 5-9 and adjust as follows:

1. Make sure the throttle linkage is connected to the governor arm and the throttle lever on the carburetor.

2. Loosen the hex. nut holding the governor lever to the cross shaft.

3. Move the governor lever **toward** the carburetor as far as it will move (wide open throttle) and hold in this position.

4. Insert a nail into the hole on the cross shaft and rotate the shaft **counterclockwise** as far as it will turn, then tighten hex. nut securely.

Sensitivity Adjustment
Governor sensitivity is adjusted by repositioning the governor spring in the holes of the governor lever. If speed surging occurs with a change in engine load, the governor is set too sensitive. If a big drop in speed occurs when normal load is applied, the governor should be set for greater sensitivity. See Figure 5-10 and adjust as follows:

1. To increase the sensitivity, move the spring closer to the governor cross shaft.

2. To decrease the sensitivity, move the spring away from the governor cross shaft.

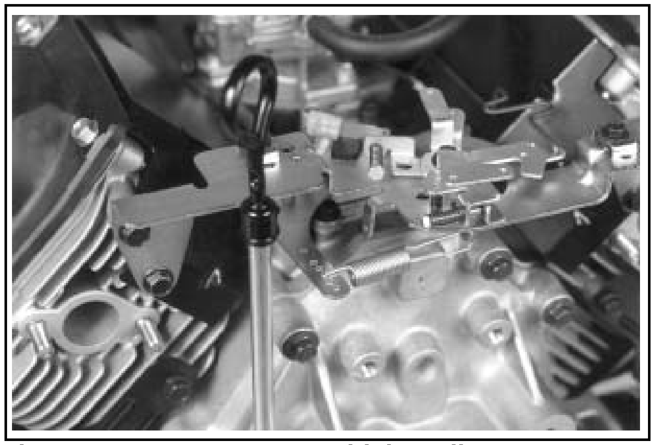


Figure 5-10. Governor Sensitivity Adjustments.

High Speed (RPM) Adjustment (Refer to Figure 5-11.)

1. With the engine running, move the throttle control to fast. Use a tachometer to check the RPM speed.

2. Loosen the lock nut on high speed adjusting screw. Turn the screw outward to decrease, or inward to increase the RPM speed. Check RPM with a tachometer.

3. When the desired RPM speed is obtained, retighten the lock nut.

NOTE: When the throttle and choke control cables are routed side-by-side, especially under a single clamp, there must be a small gap between the cables to prevent internal binding. After the high-speed setting has been completed, check that there is a gap of at least **0.5 mm (0.020 in.)** between the control cables.

5

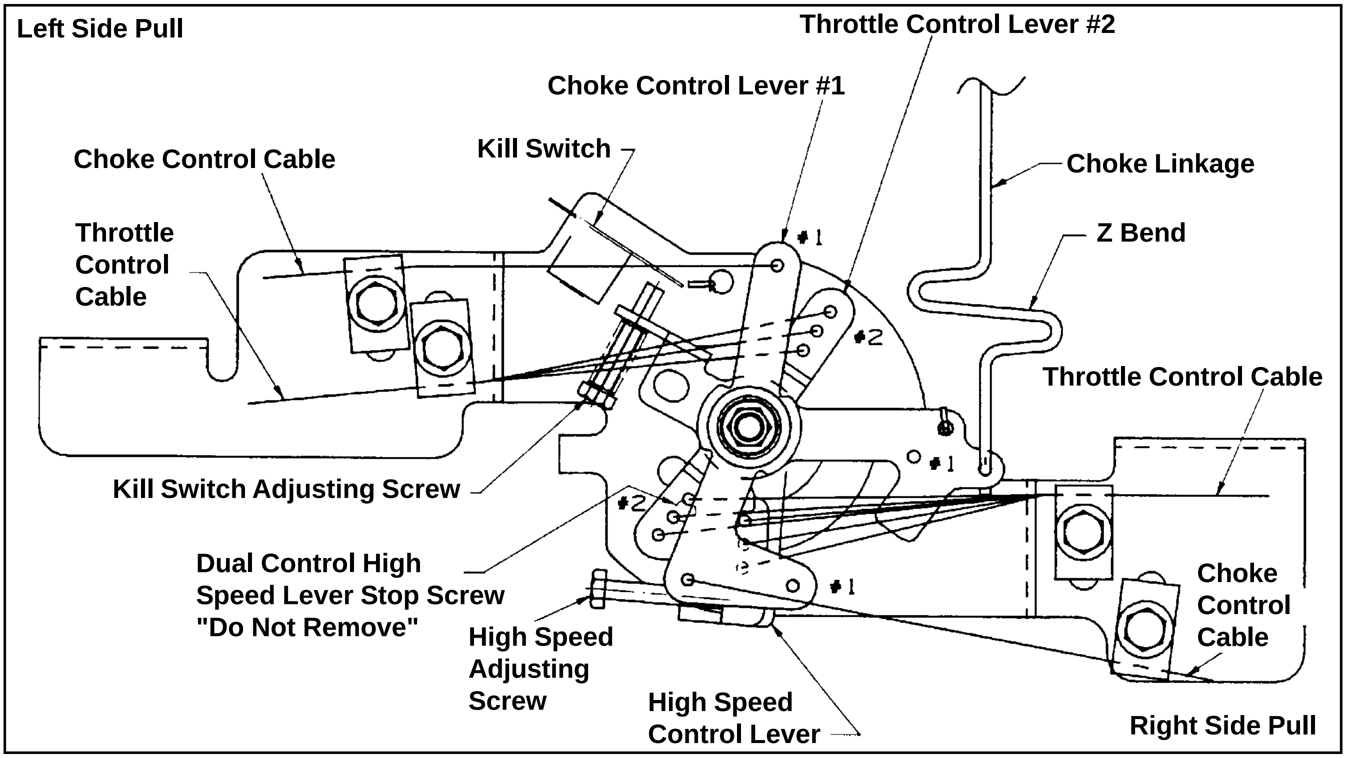


Figure 5-11. Governor Control Connections.

Electronic Governor

General

The electronic governor regulates engine speed at varying loads. It consists of a governor control unit, digital linear actuator and linkage.

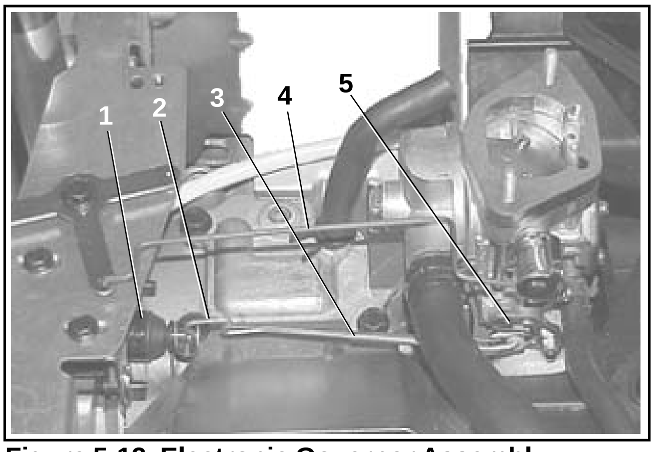


Figure 5-12. Electronic Governor Assembly.

1. Digital Linear Actuator
2. Throttle Linkage
3. Linkage Spring
4. Choke Linkage
5. Throttle Lever Adapter

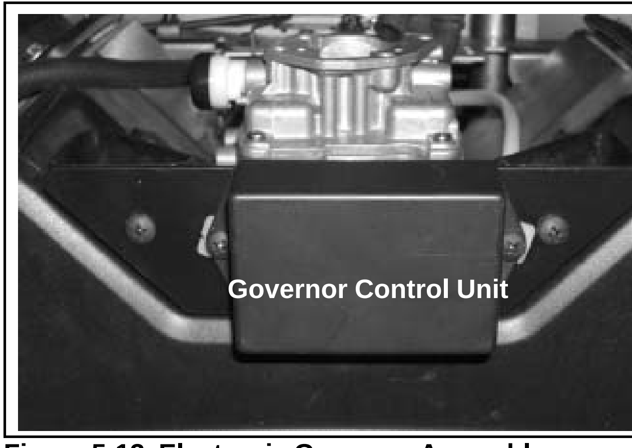


Figure 5-13. Electronic Governor Assembly.

Digital Linear Actuator (DLA)

Energizing the bi-directional digital linear actuator coils in the proper sequence, causes the threaded shaft to move out of, or back into the rotor, in precise linear increments. When power is removed, the actuator shaft remains in position. The DLA must initialize (fully extend) to move the throttle plate to the closed position, and partially open for starting. Correct adjustment of the DLA is critical to achieve the full range of throttle plate movement. See Adjustment Procedure.

Governor Control Unit (GCU) senses engine speed by pulse voltage inputs from the ignition modules. The GCU regulates the engine speed by variable input voltage from a customer-supplied potentiometer or a single pole, single throw (SPST) switch.

Potentiometer Specifications:

Wiper Voltage	Engine Speed (RPM)
0-1	1860 low speed endpoint
1-9	variable speed endpoint
9-16	3600 high speed endpoint

SPST Switch Specifications:

Switch Position	Engine Speed (RPM)
Open	1860 low speed endpoint
Closed	3600 high speed endpoint

GCU Safety Features

In the event of an engine overspeed condition, the GCU will shut down the engine by grounding the ignition modules.

The GCU will shut down the engine by grounding the ignition when power to the GCU is lost.

Linkage

The throttle linkage spring will fully open the throttle plate if the linkage becomes detached from the DLA. This will create an overspeed condition causing the engine to shut down. The DLA shaft will have to be manually screwed back into the body, and then retracted before reassembling the linkage.

Adjustment Procedure

The DLA must be in the fully retracted position during assembly. The full range of throttle plate movement will not be achieved if the DLA is partially extended when assembled. Loosen the two DLA mounting plate screws located on the top of the actuator plate. With the throttle linkage centered in the U-Clip at the end of the DLA shaft, slide the DLA bracket assembly back until the throttle plate is fully open. Torque the mounting plate screws to **2.5 N·m (22 in. lb.)**.

Troubleshooting Procedure

Engine starts, but will not continue to run

1. Check the linkage connection between the DLA and throttle plate.
2. Verify the DLA initializes when power is supplied (key switch in the start or run position).
3. Test the potentiometer wiper output voltage (if equipped).
4. Test the SPST switch (if equipped).
5. Check the wire harness and connections.

Engine does not run at the expected speed

1. Check to see that the throttle linkage and DLA have full range of motion having no mechanical interference.
2. Test the potentiometer wiper voltage (if equipped).
3. Test the SPST switch (if equipped).

Section 5A
LPG Fuel Systems

WARNING: Explosive Fuel!
LPG is extremely flammable, is heavier than air, and tends to settle in low areas where a spark or flame could ignite the gas. Do not start or operate this engine in a poorly ventilated area where leaking gas could accumulate and endanger the safety of persons in the area.

Proper service and repair of LPG fuel systems requires qualified technicians and special equipment. Many states require special licensing or certification for LPG repair shops and/or technicians. Check state and local regulations before attempting any adjustment, service, or repair of the LPG system or components. Faulty repairs by unqualified or underqualified personnel can have very serious ramifications. The information in this segment is for the exclusive use of qualified LPG service providers.

LPG Fuel System Components
The typical “liquid withdrawal” LPG fuel system consists of the following components:
- LPG Fuel Tank (Liquid Withdrawal)
- Electric Lock-Off/Filter Assembly
- Vaporizer
- LPG Regulator (Combination Primary/Secondary/Vacuum Lock-Off)
- LPG Carburetor
- High Pressure Fuel Line(s)
- Vacuum Line

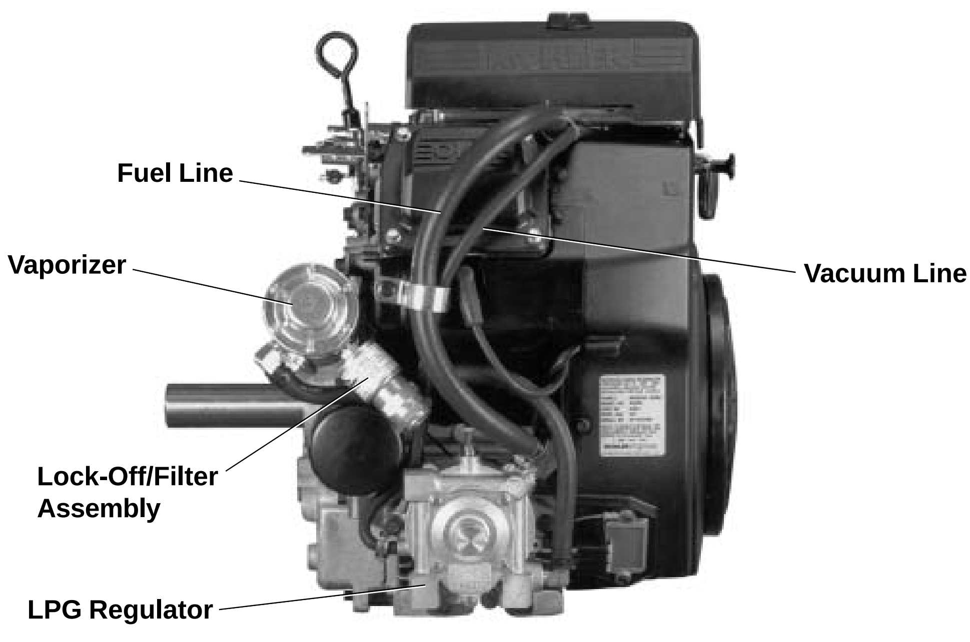


Figure 5A-1.

Operation

In a liquid withdrawal system, the Liquefied Petroleum Gas (LPG) is released from the bottom of the supply tank under high pressure. Upon opening the shut-off valve on the tank, liquid fuel travels out through the high pressure line to the electric lock-off/filter assembly. The lock-off opens internally when the key switch is turned **"on,"** permitting filtered fuel to flow to the vaporizer. The vaporizer is mounted in the flow of the discharged cooling air. It absorbs heat from the cooling air and transfers it to the fuel, changing the liquefied petroleum to a vapor or gaseous state, while partially stepping down the fuel pressure. The gas/vapor flows under this decreased pressure to the regulator where it is further reduced to a usable, regulated pressure. The regulator, activated by intake manifold vacuum, controls fuel flow to the carburetor. In the venturi of the carburetor, the fuel vapor is mixed with incoming air from the air cleaner in the correct ratio for efficient combustion.

Troubleshooting Checklist

If the engine starts hard, runs roughly, or stalls, check the following areas.

- Make sure the LPG fuel tank is filled and shut-off valve is fully opened.
- Make sure fuel is reaching the carburetor.
- Make sure the air cleaner element and precleaner are clean and all components are fastened securely.
- Make sure the ignition, governor, exhaust, throttle, and choke control systems are all operating properly.
- Check compression.

If engine continues to start hard, run roughly, or stall after these checks have been made, use the following troubleshooting guide.

Engine cranks but will not start

1. LPG fuel tank closed, low, or empty.
2. Lock-off not opening electrically, preventing fuel flow to vaporizer.
3. Fuel filter (located inside lock-off) dirty or blocked.
4. Insufficient vacuum signal, regulator not opening.
   a. Vacuum line between carburetor and regulator cracked, leaking, kinked, or pinched.
   b. Carburetor loose.
   c. Intake manifold loose or leaking.
   d. Excessive internal engine wear.
5. Faulty regulator.
   a. Primary valve not opening.
   b. Diaphragm spring adjustment incorrect.
   c. Idle adjustment screw incorrectly set.
   d. Vent(s) blocked/restricted.
6. Restricted/blocked fuel line.
7. Blocked carburetor fuel circuit.
8. Loose/leaking fuel enrichment hose (Impco carburetor system).

Hard starting, runs roughly, or stalls at idle speed

1. LPG fuel tank low.
2. Vacuum line between carburetor and regulator pinched, cracked, or leaking.
3. Carburetor idle speed set too low (should be at least 1200 RPM).
4. Carburetor idle circuit restricted.
5. Dirty/restricted air cleaner.
6. Dirty/restricted lock-off filter.
7. Frozen/malfunctioning regulator. Check/adjust primary pressure.
8. Excessive external load on engine.
9. Excessive internal wear.
10. Loose/leaking fuel enrichment hose (Impco carburetor system).

Irregular or inconsistent idle

1. Improper operation/adjustment of regulator, idle adjustment screw, throttle opening, and/or engine governor.
2. Secondary valve in regulator not closing. Readjust idle screw (couterclockwise) so valve can close fully against seat.
3. Loose/leaking vacuum line.
4. Loose carburetor mounting and/or line connections.
5. Damaged diaphragm(s) within regulator.
6. Debris in regulator. Flush debris from drain plug or remove regulator from system, disassemble body and remove debris.
7. Dirt or debris in carburetor. Remove carburetor, disassemble and clean/service as required. If venturi (Impco carburetor) removal is performed, mark its orientation to the carburetor body for proper reinstallation.
8. Loose/leaking fuel enrichment hose (Impco carburetor system).

Engine stalls during operation
1. No fuel.
2. Faulty lock-off or blocked filter.
3. Improper governor setting.
4. Damaged diaphragms within regulator.
5. Vacuum line leaking, loose, or pinched.
6. Restricted fuel line.
7. Loose/leaking fuel enrichment hose (Impco carburetor system).

Low power
1. Air cleaner or exhaust system dirty/restricted.
2. Low fuel.
3. Rich gas condition (flooding) through regulator.
   a. Dirty/restricted valves in regulator.
   b. Damaged primary diaphragm in regulator.
4. No fuel.
   a. Electric lock-off not opening, filter blocked, or restriction within fuel line.
   b. Leaking, loose, or cracked vacuum line from carburetor to regulator.
   c. Leaking, or loose intake system components.
   d. Regulator primary valve not opening.
   e. Secondary, or vacuum lock-off diaphragm within regulator leaking.
   f. Low pressure rubber hose kinked.
   g. Frozen regulator.
5. Improper ignition timing.
6. Loose/incorrect throttle lever/clamp bracket positioning.
7. Loose or incorrectly positioned high speed throttle plate stop.

Engine runs lean
1. Electrical problem causing intermittent lock-off operation, or lock-off is faulty.
2. Filter in lock-off dirty or restricted.
3. Restriction in fuel system.
4. Idle holes plugged; dirt in fuel delivery channels.
5. Carburetor fuel circuit restriction.
6. Loose/leaking fuel enrichment hose (Impco carburetor system).

High fuel consumption
1. Fuel leak. Check lines, connections, and system components for leaks with soapy water. Fix any leaks immediately.
2. Incorrectly set regulator, or leakage from valves in regulator. Readjust, service, or replace regulator as required.
3. Dirty air cleaner or precleaner.
4. Choke plate in carburetor not opening completely.

LPG Carburetor Adjustments

General
The LPG carburetor and regulator are designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The high and low idle fuel mixture settings are preset at the factory, and cannot be adjusted. These engines are equipped with an Impco or Nikki carburetor. See Figure 5A-2 and 5A-3. Although both carburetors function similarly, each is unique and should not be interchanged.

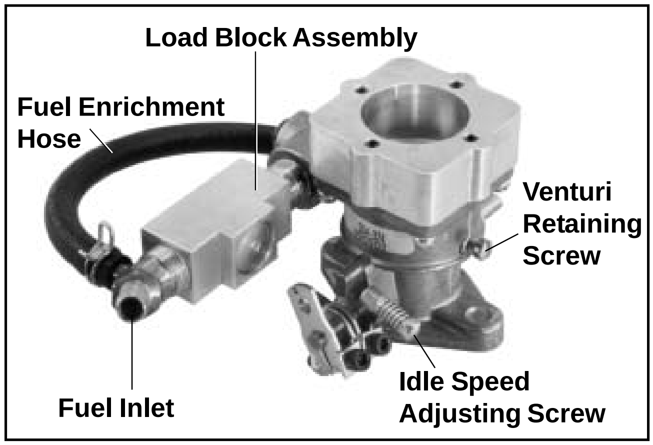


Figure 5A-2. Impco Carburetor.

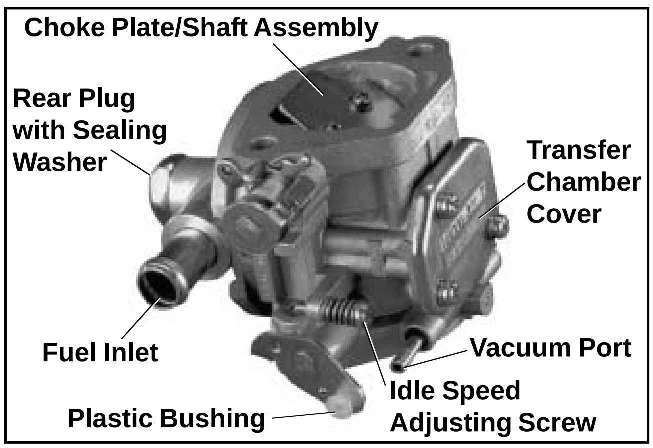


Figure 5A-3. Nikki Carburetor.

Impco carburetors also incorporate the use of an external "Load Block" assembly, which controls the final fuel flow to the carburetor for all throttle positions except idle. See Figure 5A-2. Calibrated and flow-matched to the carburetor, it functions similarly to preset fuel mixture settings in other carburetors. The load block assembly is not available separately, nor is any internal servicing permitted or possible. If a problem is encountered and determined to be caused by the load block, the carburetor should be replaced.

High Altitude Operation

The standard carburetor calibrations will provide proper operation up to altitudes of **1500 m (5000 ft.)**. No internal changes are necessary or available for either carburetor.

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

Idle Speed Adjustment

1. Start the engine and run at half throttle for 5 to 10 minutes. Check that the throttle and choke (Nikki carburetor) plates can open fully.

2. Place the throttle control into the **"idle"** or **"slow"** position. Turn the low idle speed adjusting screw (See Figure 5A-2 or 5A-3) in or out, to obtain a low idle speed of **1200 RPM (± 75 RPM),** or set to application specifications. Check the speed using a tachometer.

NOTE: The actual low idle speed (RPM) depends on the application. Refer to the equipment manufacturer's recommendations. The low idle speed for basic engines is **1200 RPM**.

LPG Fuel System Component Service

LPG Carburetor - Cleaning

The carburetor may be cleaned if necessary. Removal from the engine and limited disassembly will aid in cleaning.

NOTE: **Impco Carburetor:** Do not loosen or alter the mounted position of the clamping brackets and/or stop collar on the throttle shaft. Each is preset, in correlation to a specific position of the throttle plate (shaft), or acts as a stop. None of these attached components, including the throttle plate or shaft, requires disassembly or removal for any carburetor servicing. All the components on the throttle shaft should be left intact. If the settings of any one of these is inadvertently loosened or altered, each must be checked/reset, or performance and operation will be affected. Refer to the procedure included in the reassembly/installation sequence to check or reset.

Impco Carburetor

1. Turn off fuel supply at tank.

2. Remove the air cleaner, breather hose, fuel line, vacuum hose, choke, and throttle linkages. Remove the mounting hardware, carburetor, and gaskets from the engine. Discard the gaskets.

3. The carburetor venturi may be removed for inspection and appropriate cleaning.

   a. Remove the four screws securing the air cleaner adapter and gasket to the carburetor. See Figure 5A-4.

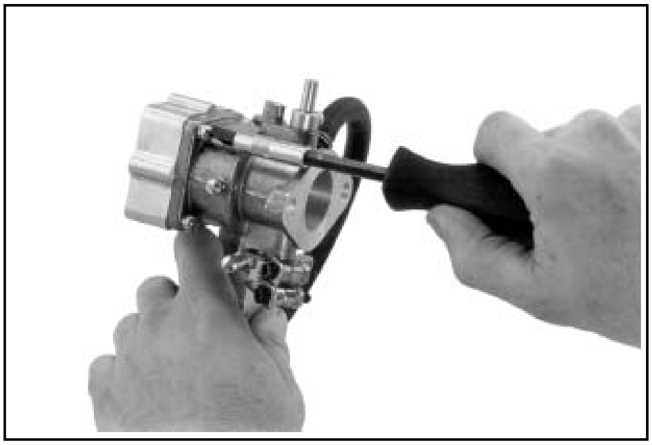


Figure 5A-4.

   b. **Important:** Mark a small line on the outer edge of the venturi for proper orientation and reinstallation later.

   c. Loosen the venturi retaining screw on the side of the carburetor body and lift out the venturi. See Figure 5A-5.

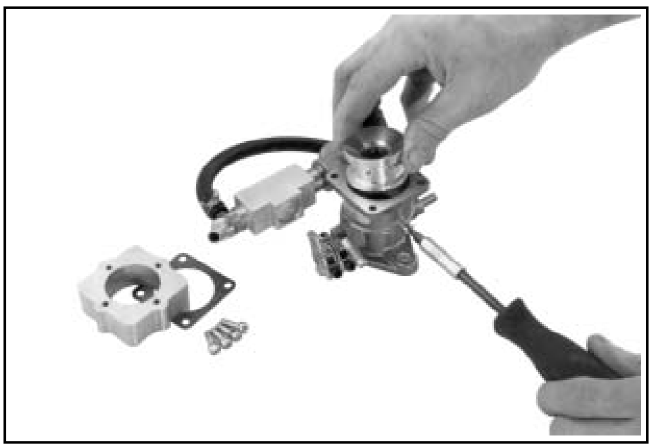


Figure 5A-5.

4. Inspect the overall condition of the fuel enrichment hose attached to the carburetor. It must be free of cracks, deterioration, and damage. Disconnect the fuel enrichment hose from the carburetor fittings to clean or check condition as required. See Figure 5A-6. Replace with a new Kohler high pressure hose (LP rated) if the condition is questionable in any way. Secure new hose using new clamps.

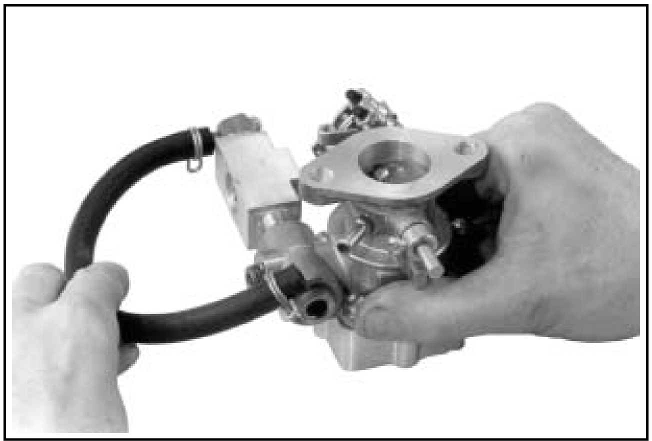


Figure 5A-6.

5. Clean all parts as required, use a good carburetor cleaner, following the manufacturer's instructions. Blow clean, compressed air through all the passages. **Do not** poke or probe into the load block assembly as damage can be done, resulting in serious operational problems. See Figure 5A-7.

Figure 5A-7.

Nikki Carburetor

1. Turn off fuel supply at tank.

2. Remove the air cleaner, breather hose, fuel line, vacuum hose, choke, and throttle linkages. Remove the nuts, carburetor, and gaskets from the engine. Discard the gaskets.

3. Remove the fuel transfer chamber cover by removing the three screws. See Figure 5A-3. Carefully remove the cover and gasket. Discard the gasket.

4. The main jet is fixed and nonadjustable, but may be accessed for cleaning by removing the rear plug and sealing washer. Discard the washer.

5. In order to clean the off-idle transfer passages and carburetor thoroughly, use a good carburetor cleaner and follow the manufacturer's instructions. Blow clean, compressed air through the passages and make sure all are open before reassembling. **Do not** use wire or metal objects to clean passages or carburetor body.

LPG Carburetor - Inspection

1. Inspect the carburetor body and removable venturi (Impco carburetor) for cracks, holes, and other wear or damage.

2. Check the choke shaft (Nikki carburetor only) and the throttle shaft for wear and free movement.

   NOTE: **Do not** attempt to disassemble or remove either shaft from the carburetor body, including the mounted clamp brackets on Impco style carburetors. The screws, attaching the choke and throttle plate to their respective shafts are staked or bonded to prevent loosening. The plate(s) and shaft(s) are not available separately. If detrimental wear or damage is found in any of the parts, the carburetor should be replaced.

LPG Carburetor - Reassembly

Impco Carburetor

1. Slide the venturi into the carburetor body, aligning the position mark made prior to removal. Correctly installed, the discharge holes should not be visible from the top.

2. Secure with the venturi retaining screw. Torque the screw to **4.0 N·m (36 in. lb.)**.

3. Install a new adapter gasket and mount the air cleaner adapter onto the carburetor with the four screws. Torque the screws to **4.0 N·m (36 in. lb.)**.

4. Install a new carburetor gasket onto the intake manifold adapter, followed by the carburetor. Install and finger tighten the mounting fasteners.

5. Connect the ''Z'' end of the throttle linkage and the dampening spring to the throttle clamp bracket on the throttle shaft. Attach the opposite end of linkage and spring to the governor lever.

   NOTE: The clamp brackets and stop collar mounted on the throttle shaft should still be in their original positions (See Figure 5A-2), and not require any readjustment/resetting. Continue with steps 6 and 7. If the mounted position of any one of these was affected or changed, it will be necessary to check and reset the position of each before proceeding. Follow the complete instructions listed after step 7, then continue with steps 6 and 7.

6. Manually move the governor lever toward the carburetor as far as it will go.

7. Check that the throttle plate is now fully open or reposition the carburetor slightly on the mounting screws so it is fully open. Torque the mounting screws to **9.9 N·m (88 in. lb.)**.

Instructions for Checking/Positioning the Clamp Brackets Mounted on the Throttle Shaft

Use only if the position or mounting of the clamp bracket(s) has been disturbed. Figures show the carburetor removed from the engine for clarity.

Idle Speed Clamp Bracket Position

1. Counting the number of turns, back the idle speed adjustment screw off (counterclockwise), so only 1 to 1 1/2 of the threads are visible. See Figure 5A-8.

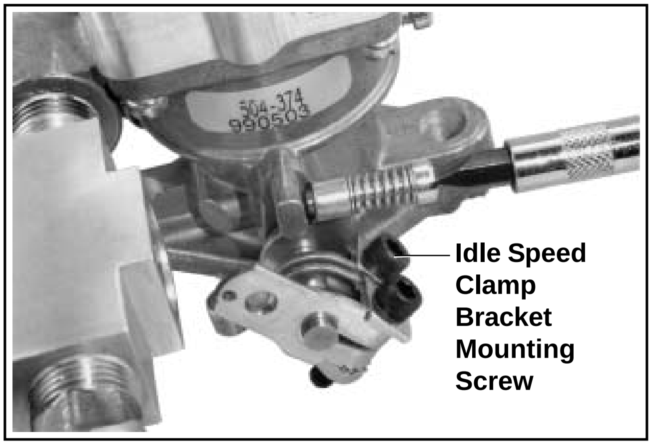


Figure 5A-8. Backing Off Idle Speed Screw.

2. Loosen the clamp bracket mounting screw, and pivot the throttle shaft to fully close the throttle plate. See Figure 5A-9.

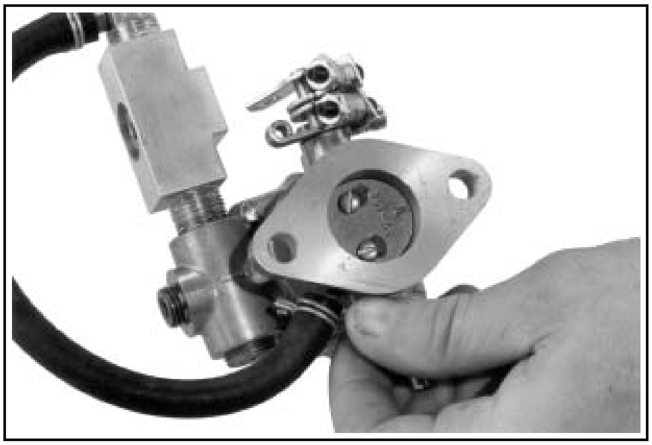


Figure 5A-9. Closing Throttle Plate.

3. Hold the throttle plate closed and rotate the clamp bracket until the end of the screw contacts the stop. Insert a 0.025 mm (0.001 in.) feeler gauge between the carburetor housing and the side of the clamp bracket to set the endplay, then tighten the mounting screw securely. See Figure 5A-10.

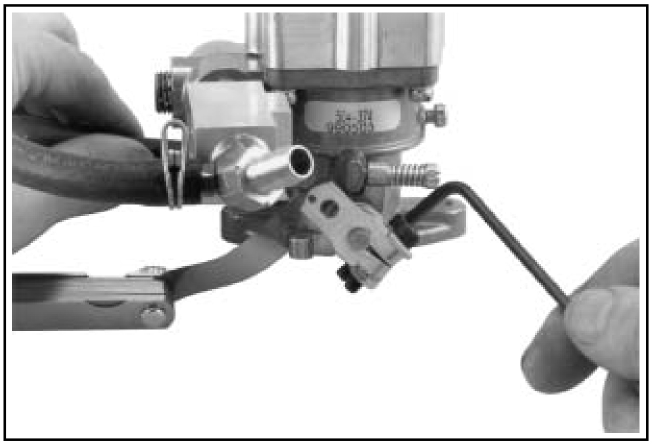


Figure 5A-10. Tightening Idle Speed Clamp Mounting Screw.

4. Reset the idle speed adjustment screw back to the original position.

High Speed/Stop Collar Position

1. Make sure the idle speed clamp position has already been checked or properly set.

2. Rotate and hold the throttle shaft so the throttle plate is fully open/perfectly vertical. See Figure 5A-11.

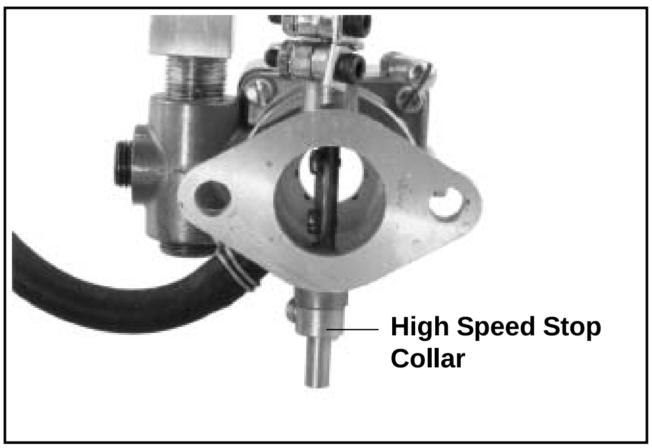


Figure 5A-11. Full Throttle Position.

3. Insert a 0.025 mm (0.001 in.) feeler gauge between the side of the stop collar and the carburetor housing, then check or set the position of the stop collar. The head of the mounting screw **must** be in contact with the carburetor boss from the back (hose/fitting) side, preventing any further rotation over center. Set or adjust the stop collar as required. See Figure 5A-12.

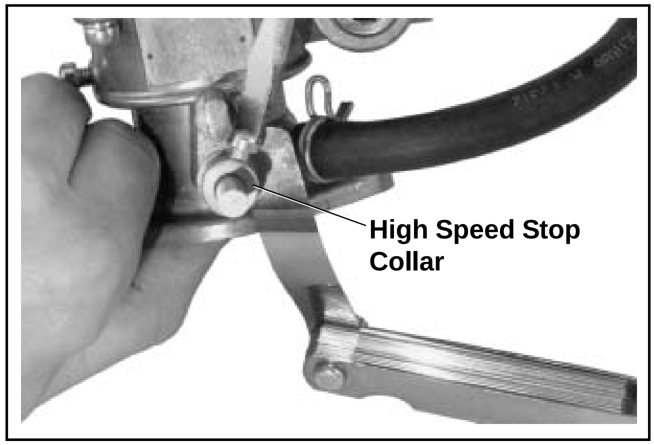


Figure 5A-12. Adjusting/Setting Stop Collar.

4. Tighten the screw securely.

NOTE: After the idle speed clamp bracket and the high speed stop collar positions have been set, check that the throttle shaft pivots freely without binding or restriction.

Throttle Linkage Clamp Bracket Position

Carburetor must be assembled to engine with linkage attached to set this position.

1. The throttle linkage clamp bracket should be positioned as shown in Figure 5A-13 on the idle speed clamp bracket side of the throttle shaft.

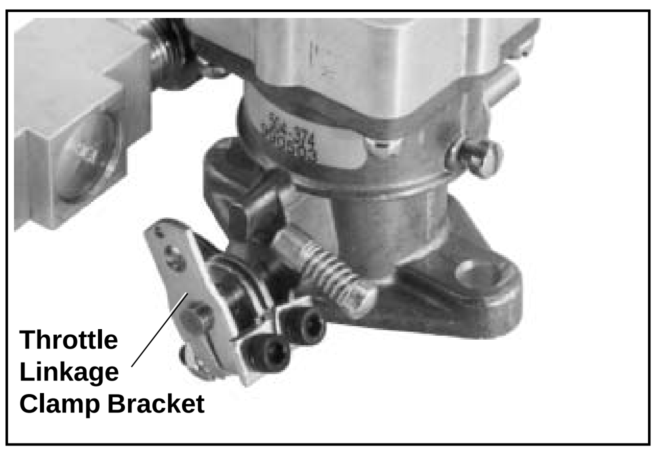


Figure 5A-13. Throttle Linkage Clamp Bracket Position.

5A

2. Manually move the governor lever, with the throttle linkage connected, toward the carburetor as far as it will go. Hold it in this position.

3. Looking down the throat of the carburetor, check that the throttle plate is in the full throttle position and that the head of the high speed collar stop screw is in contact with the carburetor boss. If not, loosen the carburetor mounting screws and reposition the carburetor slightly. Torque the carburetor mounting screws to **9.9 N·m (88 in. lb.)**.

   NOTE: If additional adjustment is required, loosen the throttle linkage clamp bracket mounting screw, set the throttle shaft to the full throttle position against the head of the stop screw, and retighten the clamp mounting screw securely. See Figure 5A-14.

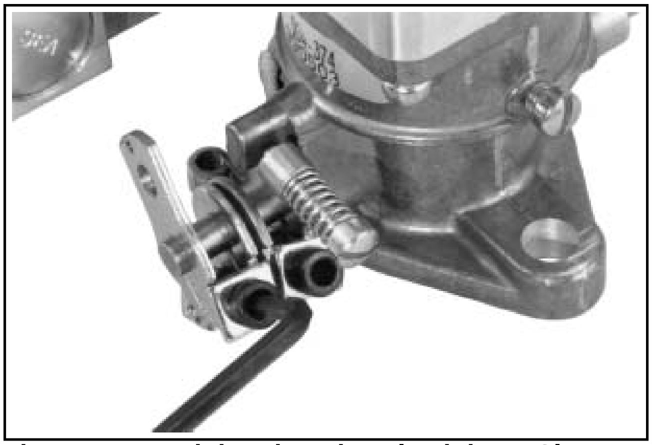


Figure 5A-14. Tightening Throttle Linkage Clamp Bracket.

Nikki Carburetor

1. Reinstall the rear plug with a new sealing washer. Tighten the plug securely.

2. Reinstall fuel transfer chamber cover with a new gasket. Secure with the three screws.

3. Install new carburetor mounting gasket on manifold studs, followed by the carburetor and new air cleaner base gasket.

4. Reconnect the throttle and choke linkages, and the fuel and vacuum lines.

5. Reinstall the air cleaner base and breather tube. Secure base with two mounting nuts. Torque nuts to **9.9 N·m (88 in. lb.)**. Install the rest of the air cleaner system.

7. Check to be sure all system connections are tight.

8. Reset idle RPM and recheck high idle (governed speed) after starting and allowing sufficient warm-up time.

Electric Lock-Off/Filter Assembly - Functional Test
The electric lock-off can be easily tested to verify that it is functional. Remove it from the system for testing. Using a 12 volt power supply or battery, connect one wire lead to the positive (+) lead of power supply, and touch remaining wire lead to negative (-) lead of power supply. When connection is made, an audible "click" should be heard indicating the opening of the lock-off. While energized, blow compressed air through it to determine if it is blocked or restricted.

Figure 5A-15.

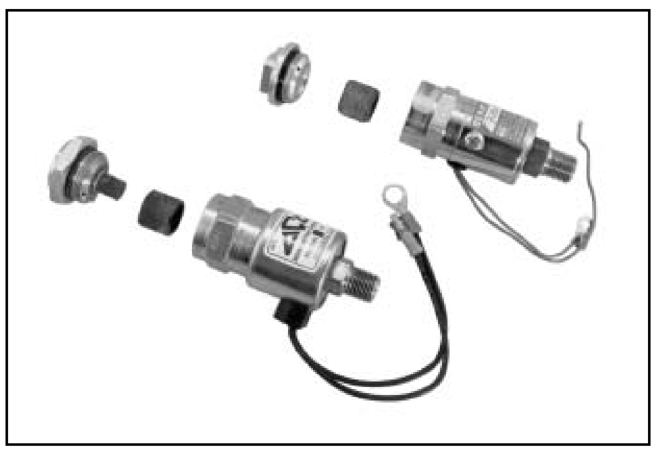


Figure 5A-16.

Electric Lock-Off/Filter Assembly - Filter Service
The filter inside the lock-off assembly should be replaced **every 500 hours** of operation, or if it becomes blocked or restricted. Cleaning of the filter element is not recommended. Order a replacement filter element by the appropriate Kohler part number.

Vaporizer Assembly

The outer surface of the vaporizer should be kept free of dirt and debris accumulation, which will cause a loss of vaporization efficiency. Visual inspection and necessary cleaning should be performed on a regular basis, more frequently under dusty or dirty conditions. The vaporizer should be disassembled, cleaned, and serviced using a rebuild kit **every 1500 hours** or if a problem is encountered.

Figure 5A-17.

LPG Regulator

The regulator controls both the pressure and flow of fuel within the LP system. It is comprised of both a primary and secondary chamber, which are dependent upon one another. Two different styles of regulators are used, based upon the system involved. The Impco (Beam) regulator is shown in Figure 5A-18, and the Nikki regulator is shown in Figure 5A-19. Although the basic design and operating principles are similar, due to system differences the regulators should not be interchanged.

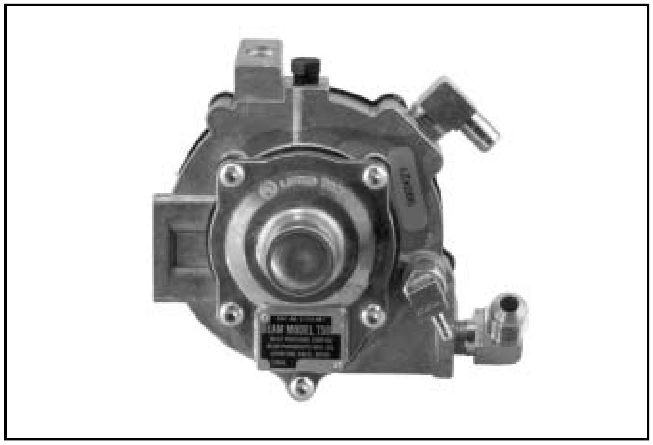


Figure 5A-18. Impco (Beam) Regulator.

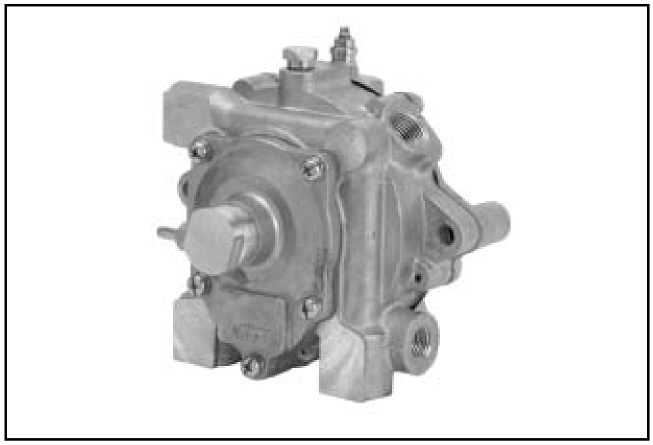


Figure 5A-19. Nikki Regulator.

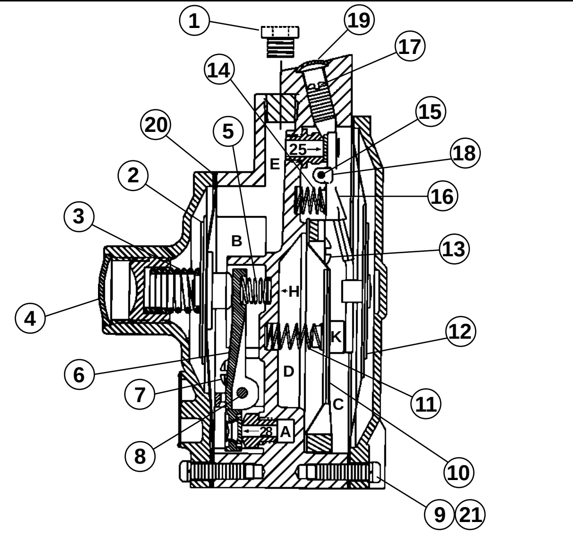
Following are separate sections covering the theory of operation and general service information for each style of regulator. Detailed service/repair instructions are included in the rebuild kit for each regulator.

Impco (Beam) Regulator (See Figure 5A-20)
LPG vapor enters at point **(A)**, then passes into primary area **(B)** at point **(28)**, where pressure is reduced from up to 250 psi at the tank to 4.5 psi in area **(B)**. Fuel pressure against diaphragm **(2)** overcomes spring **(3)** and as movement increases, spring **(5)** will close lever **(6)**. The primary diaphragm breather (not shown in drawing) is vented to secondary chamber so that rupture of this diaphragm would direct fuel into the carburetor.

Fuel now moves through passage **(E)**, past secondary valve **(25)** into secondary area **(C)**. As negative pressure (vacuum) is created at the carburetor venturi and is transmitted through the dry-gas hose to chamber **(C)** secondary diaphragm **(12)** is drawn down and contacts the secondary lever **(16)**. Fuel will flow in proportion to air velocity through the carburetor venturi, ensuring an ideal mixture at all engine speeds.

Whenever the engine is operating, the vacuum diaphragm **(10)** is down against the floor **(H)** and the spring **(11)** is compressed. The idle and starting adjustment is made with a tamper-resistant screw **(17)** which regulates the whisker wire system (not shown), opening up the secondary orifice slightly (but only when the vacuum diaphragm is drawn down). Very little vacuum is needed to start this vacuum diaphragm travel: 0.2" Mercury to start and 0.5" Mercury for full travel. The instant the engine stops rotating, loss of vacuum in section **(D)** releases diaphragm **(10)** causing bumper **(K)** to push against secondary lever **(16)**, overcoming action of whisker wire and ensuring 100% lock off.

This patented Beam design will lock off primary pressures up to five times in excess of normal and permits starting without priming or choking.

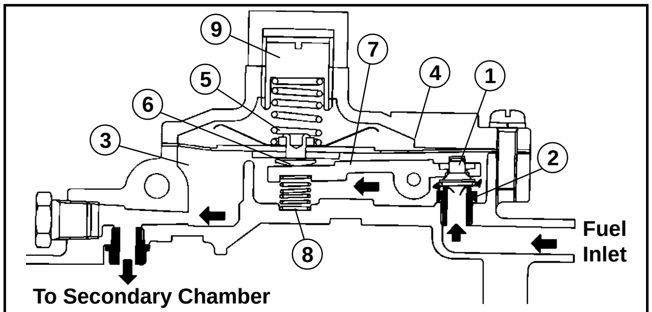


1) 1/8-27 NPT Plug
2) Primary Diaphragm Assembly
3) Primary Spring
4) Expansion Plug
5) Secondary Diaphragm Spring
6) Primary Lever Assembly
7) Fillister Head Screw
8) Primary Pivot Pin
9) Torx Head Screw
10) Vac Lock Diaphragm Assembly
11) Vac Lock Spring
12) Secondary Diaphragm
13) Pan Head Screw
14) Secondary Lever Spring
15) Secondary Pivot Pin
16) Secondary Lever Assembly
17) Adjustment Screw
18) Pan Head Screw
19) Expansion Plug
20) Diaphragm Gasket
21) Split Lock Washer

Figure 5A-20.

Nikki Regulator Primary Chamber (See Figure 5A-21)

The primary chamber reduces the high pressure fuel flow from the tank and vaporizer down to approximately 4 psi. Fuel flowing from the vaporizer enters the inlet of the regulator under approximately **76 kPa (11 psi)** of pressure. There it is delivered to the primary chamber **(3)** through the clearance between the primary valve **(1)** and valve seat **(2)**. As fuel continues to flow and the primary chamber approaches **29 kPa (4 psi)**, the primary diaphragm **(4)** overcomes the tension of the diaphragm spring **(5)**. As the diaphragm **(4)** and contact button **(6)** move up, the primary lever spring **(8)** pushes the primary lever **(7)** up, in turn closing the primary valve **(1)** and stopping the flow of fuel. As fuel is consumed and the pressure in the primary chamber drops below **29 kPa (4 psi)**, the diaphragm spring **(5)** tension will be greater than the fuel pressure, causing the primary diaphragm **(4)** to be pushed down. This causes the contact button **(6)**, to push the primary lever **(7)** down, in turn opening the primary valve **(1)** and admitting more fuel. In this manner, the pressure within the primary chamber is maintained at a relatively constant **29 kPa (4 psi)**.



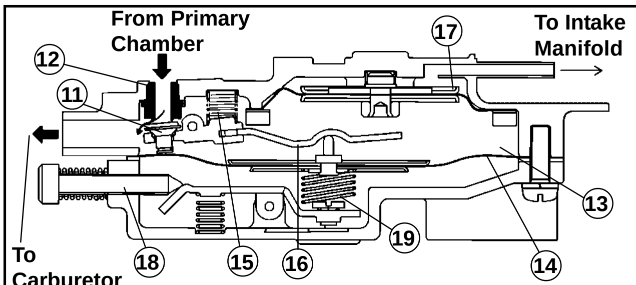
1) Primary Valve
2) Primary Valve Seat
3) Primary Chamber
4) Primary Diaphragm
5) Primary Diaphragm Spring Adjustment
6) Contact Button
7) Primary Valve Lever
8) Primary Lever Spring
9) Primary Pressure

Figure 5A-21. Primary Chamber.

Nikki Regulator Secondary Chamber (See Figure 5A-22)

The secondary chamber further reduces the fuel pressure from the **29 kPa (4 psi)** of the primary chamber to near **0 kPa (0 psi)** pressure, to prevent excessive fuel flow to the carburetor. Fuel enters the secondary chamber **(13)** through the clearance between the secondary valve **(11)** and the valve seat **(12)**. While the engine is operating, and fuel is being drawn from the secondary chamber, the secondary diaphragm **(14)** is raised by atmospheric pressure, simultaneously lifting the secondary valve lever **(16)**, opening the secondary valve **(11)**, allowing fuel to flow. When the engine is running at idle, there may not be enough vacuum created in the carburetor venturi to overcome the tension of the secondary diaphragm spring **(15)**, and the secondary diaphragm cannot open the valve. Under those conditions, the idle adjusting screw **(18)**, and balance spring **(19)** are used to apply just enough pressure on the diaphragm **(14)** to maintain sufficient fuel flow for idle operation.

The vacuum lock-off mechanism is located in the secondary chamber. When the engine is running, manifold vacuum above the diaphragm **(17)** draws it up, so the secondary valve can function normally. When the engine is stopped, manifold vacuum is terminated, and the diaphragm relaxes and pushes down on the secondary valve lever, preventing any fuel flow or leakage through the regulator.



11) Secondary Valve
12) Secondary Valve Seat
13) Secondary Chamber
14) Secondary Diaphragm
15) Secondary Diaphragm Spring
16) Secondary Valve Lever
17) Vacuum Lock-Off Diaphragm
18) Idle Adjust Screw
19) Balance Spring

Figure 5A-22. Secondary Chamber.

5A

Preventative Maintenance
The regulator is preset at the factory and generally requires no further adjustment. No periodic service is required. Over time, depending on fuel quality, operating environment, and system performance, fuel deposits can accumulate inside the regulator. Those regulators containing a drain plug (Nikki) should be drained every **500 hours** to remove any accumulated deposits. See Figure 5A-23.

Figure 5A-23. Regulator Drain Plug (some models).

1. Turn supply valve off, run engine out of fuel, and turn off ignition switch.

2. Disconnect and ground the spark plug leads.

3. Remove the 1/8" pipe plug from bottom of regulator and drain any accumulated deposits. See Figure 5A-23.

4. Reinstall plug using pipe sealant with Teflon® (Loctite® 592 or equivalent) on threads and tighten securely. If required, a replacement plug is available as Kohler Part No. X-75-23-S.

Regulator Service
Every 1500 hours it is recommended that disassembly, cleaning, and resetting of the regulator be performed using the regulator rebuilding kit available. Specific instructions are included in the rebuilding kit. Perform the regulator service following the instructions provided. As all adjustments and settings must be reset using specific test equipment, this must be performed by qualified LP personnel only.

Impco (Beam) Regulator Service
Kohler repair kit 24 757 40-S should be used to service the regulator **every 1500 hours,** or whenever cleaning and servicing is required.

Nikki Regulator Service
Kohler repair kit 24 757 39-S should be used **every 1500 hours**.

Section 5B
Electronic Fuel Injection (EFI)
Fuel System

Contents **Page(s)**

Description

⚠ WARNING

Explosive Fuel can cause fires and severe burns.

Fuel system ALWAYS remains under HIGH PRESSURE.

⚠ WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

The EFI fuel system remains under high pressure, even when the engine is stopped. Before attempting to service any part of the fuel system, the pressure must be relieved. Pressure tester, SPX Part No. KO3217-4 has an integral relief valve. Connect the black tester hose to the test valve in the fuel rail. Route the clear hose into a portable gasoline container. Depress the button on the tester relief valve.

Initial Starting/Priming Procedure

Important: The EFI fuel system must be purged of all air prior to the initial start up, and/or any time the system has been disassembled. On most engines, that can be done similar to relieving fuel pressure, as described above.

Test Valve in Fuel Rail:

1. Connect the pressure gauge as described above for relieving fuel pressure. Depress and hold the release button and crank the engine in 10-15 second intervals, allowing a 60 second cool-down period between intervals, until air is purged and fuel is visible in discharge tube.

2. If you do not have the pressure gauge, follow the procedure for engines without a test valve.

NO Test Valve in Fuel Rail:

1. Crank the engine in 10-15 second intervals, allowing a 60 second cool-down period between cranking intervals, until the engine starts.

NOTE: The number of cranking intervals necessary will depend on the individual system design, and/or where the system has been disassembled.

Fuel Recommendations

General Recommendations

Purchase gasoline in small quantities and store in clean, approved containers. An approved container with a capacity of 2 gallons or less with a pouring spout is recommended. Such a container is easier to handle and helps prevent spillage during refueling.

- Do not use gasoline left over from the previous season, to minimize gum deposits in your fuel system, and to ensure easy starting.

- Do not add oil to the gasoline.

- Do not overfill the fuel tank. Leave room for the fuel to expand.

Fuel Type

Do not use leaded gasoline, as component damage will result. Any costs/damages incurred as a result of using leaded fuel will not be warranted. Use only clean, fresh, unleaded gasoline with a pump sticker octane rating of 87 or higher. In countries using the Research method, it should be 90 octane minimum.

Gasoline/Alcohol blends

Gasohol (up to 10% ethyl alcohol, 90% unleaded gasoline by volume) is approved as a fuel for Kohler EFI engines. Other gasoline/alcohol blends are not approved.

Gasoline/Ether blends

Methyl Tertiary Butyl Ether (MTBE) and unleaded gasoline blends (up to a maximum of 15% MTBE by volume) are approved as a fuel for Kohler EFI engines. Other gasoline/ether blends are not approved.

EFI Fuel System Components

General
The Electronic Fuel Injection (EFI) system is a complete engine fuel and ignition management design. The system includes the following principal components:

- Fuel Pump
- Fuel Filter
- Fuel Rail
- Fuel Line(s)
- Fuel Pressure Regulator
- Fuel Injectors
- Throttle Body/Intake Manifold
- Engine Control Unit (ECU)
- Ignition Coils
- Engine (Oil) Temperature Sensor
- Throttle Position Sensor (TPS)
- Speed Sensor
- Oxygen Sensor
- Wire Harness Assembly & Affiliated Wiring,
- Malfunction Indicator Light (MIL)

Operation

The EFI system is designed to provide peak engine performance with optimum fuel efficiency and lowest possible emissions. The ignition and injection functions are electronically controlled, monitored and continually corrected during operation to maintain the theoretical ideal or “stoichiometric” air/fuel ratio of 14.7:1.

The central component of the system is the Motronic™ Engine Control Unit (ECU) which manages system operation, determining the best combination of fuel mixture and ignition timing for the current operating conditions.

An electric fuel pump is used to move fuel from the tank through the fuel line and in-line fuel filter. A fuel pressure regulator maintains a system operating pressure of 39 psi and returns any excess fuel to the tank. At the engine, fuel is fed through the fuel rail and into the injectors, which inject it into the intake ports. The ECU controls the amount of fuel by varying the length of time that the injectors are “on.” This can range from 1.5-8.0 milliseconds depending on fuel requirements. The controlled injection of the fuel occurs each crankshaft revolution, or twice for each 4-stroke cycle. One-half the total amount of fuel needed for one firing of a cylinder is injected during each injection. When the intake valve opens, the fuel/air mixture is drawn into the combustion chamber, ignited, and burned.

The ECU controls the amount of fuel injected and the ignition timing by monitoring the primary sensor signals for engine temperature, speed (RPM), and throttle position (load). These primary signals are compared to preprogrammed “maps” in the ECU computer chip, and the ECU adjusts the fuel delivery to match the mapped values. An oxygen sensor provides continual feedback to the ECU based upon the amount of unused oxygen in the exhaust, indicating whether the fuel mixture being delivered is rich or lean. Based upon this feedback, the ECU further adjusts fuel input to reestablish the ideal air/fuel ratio. This operating mode is referred to as “closed loop” operation. The EFI system operates “closed loop” when all three of the following conditions are met:

a. The oil temperature is greater than 35°C (95°F).

b. The oxygen sensor has warmed sufficiently to provide a signal (minimum 375°C, 709°F).

c. Engine operation is at a steady state (not starting, warming up, accelerating, etc.).

During “closed loop” operation the ECU has the ability to readjust temporary and learned adaptive controls, providing compensation for changes in overall engine condition and operating environment, so it will be able to maintain the ideal air/fuel ratio of 14.7:1. The system requires a minimum engine oil temperature greater than 55°C (130°F) to properly adapt. These adaptive values are maintained as long as the ECU is “powered up” by the battery.

During certain operating periods such as cold starts, warm up, acceleration, etc., an air/fuel ratio richer than 14.7:1 is required and the system operates in an “open loop” mode. In “open loop” operation the monitoring of exhaust gases (output) is not used, and the controlling adjustments are based on the primary sensor signals and programmed maps only. The system operates “open loop” whenever the three conditions for closed loop operation (above) are not being met.

Important Service Notes!

- Cleanliness is essential and must be maintained at all times when servicing or working on the EFI system. Dirt, even in small quantities, can cause significant problems.
- Clean any joint or fitting with parts cleaning solvent before opening to prevent dirt from entering the system.
- Always depressurize the fuel system through the test valve in fuel rail before disconnecting or servicing any fuel system components. See fuel warning on page 5B.2.
- Never attempt to service any fuel system component while engine is running or ignition switch is ''on.''
- Do not use compressed air if the system is open. Cover any parts removed and wrap any open joints with plastic if they will remain open for any length of time. New parts should be removed from their protective packaging just prior to installation.
- Avoid direct water or spray contact with system components.
- Do not disconnect or reconnect the wiring harness connector to the control unit or any individual components with the ignition ''on.'' This can send a damaging voltage spike through the ECU.
- Do not allow the battery cables to touch opposing terminals. When connecting battery cables attach the positive (+) cable to positive (+) battery terminal first, followed by negative (-) cable to negative (-) battery terminal.
- Never start the engine when the cables are loose or poorly connected to the battery terminals.
- Never disconnect battery while engine is running.
- Never use a quick battery charger to start the engine.
- Do not charge battery with key switch ''on.''
- Always disconnect negative (-) battery cable lead before charging battery, and also unplug harness from ECU before performing any welding on equipment.

Electrical Components

Electronic Control Unit (ECU)

Figure 5B-1. "35 Pin" (MA 1.7) Metal-Cased ECU.

Figure 5B-2. "24 Pin" (MSE 1.0) Plastic-Cased ECU.

Figure 5B-3. "32 Pin" (MSE 1.1) Plastic-Cased ECU.

Three different styles of ECU's have been utilized in EFI production. The first style is easily identified by its metal case with large 35 pin connector block, and also as **MA 1.7**. See Figure 5B-1. The second and third styles have plastic cases, but are smaller in overall size. These have either a 24 pin or 32 pin connector block and identified as **MSE 1.0** or **MSE 1.1** respectively. See Figures 5B-2 and 5B-3. Basic function and operating control remains the same between the three, however, due to differences in the internal circuitry as well as the wiring harness, none of the ECU's are interchangeable. Certain individual service/troubleshooting procedures also apply, where applicable, they are covered individually as: "35 Pin" (MA 1.7) Metal-Cased ECU, "24 Pin" (MSE 1.0) Plastic-Cased ECU, or "32 Pin" (MSE 1.1) Plastic-Cased ECU.

General

The ECU is the brain or central processing computer of the entire EFI fuel/ignition management system. During operation, sensors continuously gather data which is relayed through the wiring harness to input circuits within the ECU. Signals to the ECU include: ignition (on/off), crankshaft position and speed (RPM), throttle position, oil temperature, exhaust oxygen levels, and battery voltage. The ECU compares the input signals to the programmed maps in its memory to determine the appropriate fuel and spark requirements for the immediate operating conditions. The ECU then sends output signals to set the injector duration and ignition timing.

The ECU continually performs a diagnostic check of itself, each of the sensors, and the system performance. If a fault is detected, the ECU turns on the Malfunction Indicator Light (MIL) on the equipment control panel, stores the fault code in its fault memory, and goes into a default operating mode. Depending on the significance or severity of the fault, normal operation may continue, or "limp home" operation (slowed speed, richer running) may be initiated. A technician can access the stored fault code using a "blink code" diagnosis flashed out through the MIL. An optional computer software diagnostic program is also available, order Kohler Part No. **25 761 23-S**.

The ECU requires a minimum of 7.0 volts to operate. The adaptive memory in the ECU is operational the moment the battery cables are connected, however the adapted values are lost if the battery becomes disconnected for any reason. The ECU will "relearn" the adapted values if the engine is operated for 10-15 minutes at varying speeds and loads after the oil temperature exceeds 55°C (130°F).

To prevent engine over-speed and possible failure, a "rev-limiting" feature is programmed into the ECU. If the maximum RPM limit (4125 RPM on MA 1.7, 4500 RPM on MSE 1.0 & MSE 1.1) is exceeded, the ECU suppresses the injection signals, cutting off the fuel flow. This process repeats itself in rapid succession, limiting operation to the preset maximum.

Service

Never attempt to disassemble the ECU. It is sealed to prevent damage to internal components. Warranty is void if the case is opened or tampered with in any way.

All operating and control functions within the ECU are preset. No internal servicing or readjustment may be performed. If a problem is encountered, and you determine the ECU to be faulty, contact your source of supply. Do not replace the ECU without factory authorization.

The relationship between the ECU and the throttle position sensor (TPS) is very critical to proper system operation. If the TPS or ECU is changed, or the mounting position of the TPS is altered, the applicable "TPS Initialization Procedure" (see pages 5B.8 or 5B.9) must be performed to restore the synchronization.

Engine Speed Sensor

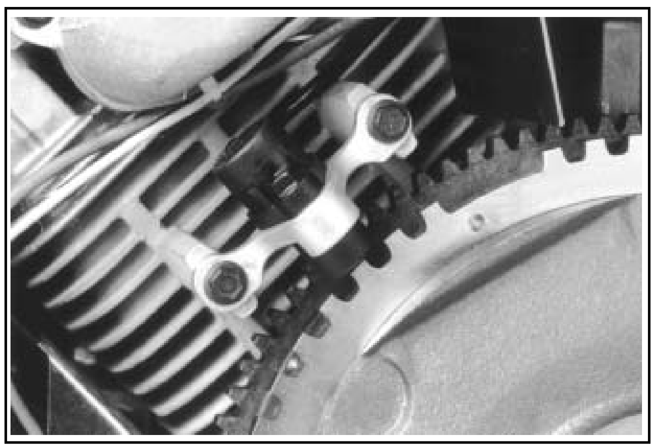


Figure 5B-4. Engine Speed Sensor.

General

The engine speed sensor is essential to engine operation; constantly monitoring the rotational speed (RPM) of the crankshaft. A ferromagnetic 60-tooth ring gear with two consecutive teeth missing is mounted on the flywheel. The inductive speed sensor is mounted **1.5 ± 0.25 mm (0.059 ± 0.010 in.)** away from the ring gear. During rotation, an AC voltage pulse is created within the sensor for each passing tooth. The ECU calculates engine speed from the time interval between the consecutive pulses. The two-tooth gap creates an interrupted input signal, corresponding to specific crankshaft position (84° BTDC) for cylinder #1. This signal serves as a reference for the control of ignition timing by the ECU. Synchronization of the inductive speed pickup and crankshaft position takes place during the first two revolutions each time the engine is started. The sensor must be properly connected at all times. If the sensor becomes disconnected for any reason, the engine will quit running.

Service

The engine speed sensor is a sealed, non-serviceable assembly. If "Fault Code" diagnosis indicates a problem within this area, check and test as follows.

1. Check the mounting and air gap of sensor. It must be **1.5 mm ± 0.25 mm (0.059 ± 0.009 in.)**.

2. Inspect the wiring and connections for damage or problems.

3. Make sure the engine has resistor type spark plugs.

4. Disconnect main harness connector from ECU.

5. Connect an ohmmeter between the designated pin terminals in the plug:

   "35 Pin" (MA 1.7) Metal-Cased ECU: #3 and #21 pin terminals.

   "24 Pin" (MSE 1.0) Plastic-Cased ECU: #9 and #10 pin terminals.

   "32 Pin" (MSE 1.1) Plastic-Cased ECU: #9 and #10 pin terminals.

   See pages 5B.28-5B.33 according to ECU style. A resistance value of **750-1000 Ω** at room temperature (20°C, 68°F) should be obtained.
   If resistance is correct, check the mounting, air gap, toothed ring gear (damage, runout, etc.), and flywheel key.

6. Disconnect the speed sensor connector from wiring harness. It is the connector with one heavy black lead (see Figure 5B-5). Viewing the connector as shown (dual aligning rails on top), test the resistance between the terminals indicated. A reading of **750-1000 Ω** should again be obtained.

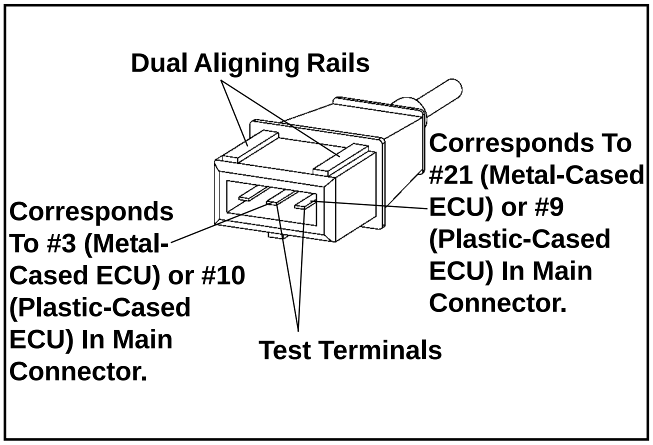
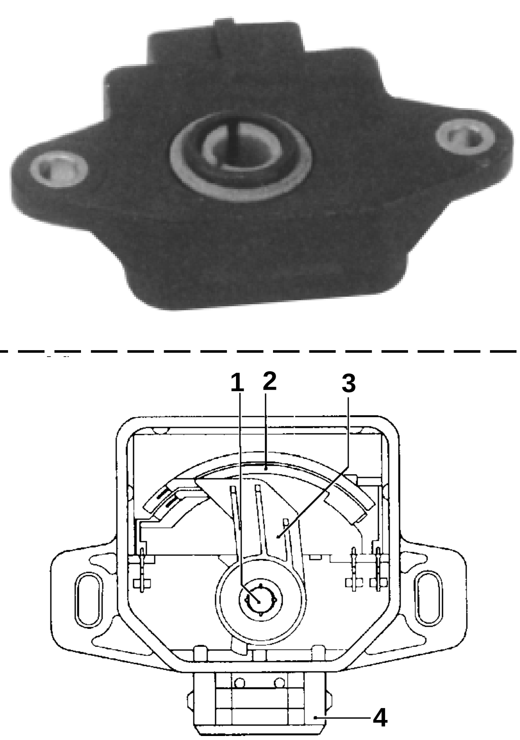


Figure 5B-5. Speed Sensor Connector.

7. a. If the resistance is incorrect, remove the screw securing the sensor to the mounting bracket and replace the sensor.

   b. If the resistance in step 5 was incorrect, but the resistance of the sensor alone was correct, test the main harness circuits between the sensor connector terminals and the corresponding pin terminals in the main connector. Correct any observed problem, reconnect the sensor, and perform step 5 again.

Throttle Position Sensor (TPS)



1. Throttle Valve Shaft
2. Resistor Track
3. Wiper Arm w/Wiper
4. Electrical Connection

Figure 5B-6. Throttle Position Sensor Details.

General
The throttle position sensor (TPS) is used to indicate throttle plate angle to the ECU. Since the throttle (by way of the governor) reacts to engine load, the angle of the throttle plate is directly proportional to the load on the engine.

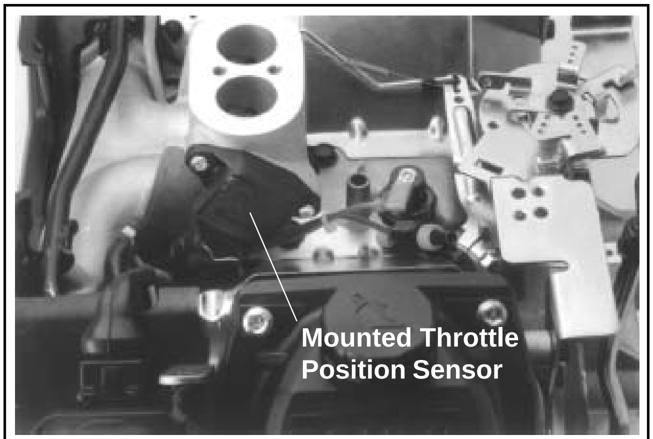


Figure 5B-7. TPS Location.

Mounted on the throttle body/intake manifold and operated directly off the end of the throttle shaft, the TPS works like a rheostat, varying the voltage signal to the ECU in direct correlation to the angle of the throttle plate. This signal, along with the other sensor signals, is processed by the ECU and compared to the internal preprogrammed maps to determine the required fuel and ignition settings for the amount of load.

The correct position of the TPS is established and set at the factory. Do not loosen the TPS or alter the mounting position unless absolutely required by fault code diagnosis or throttle shaft service. If the TPS is loosened or repositioned the appropriate "TPS Initialization Procedure" (pages 5B.8-5B.10) **must** be performed to reestablish the baseline relationship between the ECU and the TPS.

Service
The TPS is a sealed, non-serviceable assembly. If diagnosis indicates a bad sensor, complete replacement is necessary. If a blink code indicates a problem with the TPS, it can be tested as follows.

1. Counting the number of turns, back out the idle speed adjusting screw (counterclockwise) until the throttle plates can be closed completely.

2. Disconnect the main harness connector from the ECU, but leave the TPS mounted to the throttle body/manifold.

3. Connect the ohmmeter leads as follows:
   (See chart on pages 5B.28, 5B.31, or 5B.32).

   "35 Pin" (MA 1.7) Metal-Cased ECU: Red (positive) ohmmeter lead to #12 pin terminal, and Black (negative) ohmmeter lead to #27 pin terminal.

   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Red (positive) ohmmeter lead to #8 pin terminal, and Black (negative) ohmmeter lead to #4 pin terminal.

   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Red (positive) ohmmeter lead to #8 pin terminal, and Black (negative) ohmmeter lead to #4 pin terminal.

Hold the throttle closed and check the resistance. It should be **800-1200 Ω**.

4. Leave the leads connected to the pin terminals as described in step 3. Rotate the throttle shaft slowly counterclockwise to the full throttle position. Monitor the dial during rotation for indication of any momentary short or open circuits. Note the resistance at the full throttle position. It should be **1800-3000 Ω**.

5. Disconnect the main wiring harness connector from the TPS, leaving the TPS assembled to the manifold. Refer to the chart below and perform the resistance checks indicated between the terminals in the TPS switch, with the throttle in the positions specified.

Throttle Position	Between Terminals	Resistance Value (Ω)	Continuity
Closed	2 & 3	800-1200	Yes
Closed	1 & 3	1800-3000	Yes
Full	2 & 3	1800-3000	Yes
Full	1 & 3	800-1200	Yes
Any	1 & 2	1600-2500	Yes

If the resistance values in steps 3, 4, and 5 are within specifications, go to step 6.

If the resistance values are not within specifications, or a momentary short or open circuit was detected during rotation (step 4), the TPS needs to be replaced, go to step 7.

6. Check the TPS circuits (input, ground) between the TPS plug and the main harness connector for continuity, damage, etc. See chart on pages 5B.28, 5B.31, or 5B.32.

   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin Circuits #12 and #27.

   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin Circuits #8 and #4.

   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin Circuits #8 and #4.

   a. Repair or replace as required.

   b. Turn the idle speed screw back in to its original setting.

   c. Reconnect connector plugs, start engine and retest system operation.

7. Remove the two mounting screws from the TPS. Save the screws for reuse. Remove and discard the faulty TPS. Install the replacement TPS and secure with the original mounting screws.

   a. Reconnect both connector plugs.

   b. Perform the appropriate "TPS Initialization Procedure" integrating the new sensor to the ECU.

TPS Initialization Procedure
For "35 Pin" (MA 1.7) Metal-Cased ECU and
"24 Pin" (MSE 1.0) Plastic-Cased ECU only

1. Check that the basic engine, all sensors, fuel, fuel pressure, and battery are good and functionally within specifications.

Important!
2. Remove/disconnect ALL external loads from engine (belts, pumps, electric PTO clutch, alternator, rectifier-regulator, etc.).

3. Start the engine and allow it to warm up for 5-10 minutes, so oil temperature is above 55°C (130°F).

4. Move the throttle control to the idle position and allow engine to stabilize for a minimum of one minute.

5. Install a heavy rubber band around the throttle lever and the manifold boss, to firmly hold the throttle against the idle stop. On some EFI engines there is a dampening spring on the end of the idle speed screw. The dampening spring (if used) should be fully compressed and the tab on the throttle lever in direct contact with the speed screw. Adjust the idle speed to 1500 RPM, using a tachometer.

6. Shut off engine.

7. Locate the service connector plug in the wiring harness.

   "35 Pin" (MA 1.7) Metal-Cased ECU: Connect a jumper wire from the TPS initialization pin #8 (gray wire) to the ground pin (black wire), or use jumper plug (SPX Part No. **KO3217-7**, with red jumper wire). See Figure 5B-8.

"24 Pin" (MSE 1.0) Plastic-Cased ECU:
Connect a jumper wire from the TPS initialization pin #24 (violet wire) to the battery voltage pin (red wire), or use jumper plug (SPX Part No. **KO3217-9**, with blue jumper wire). See Figure 5B-9.

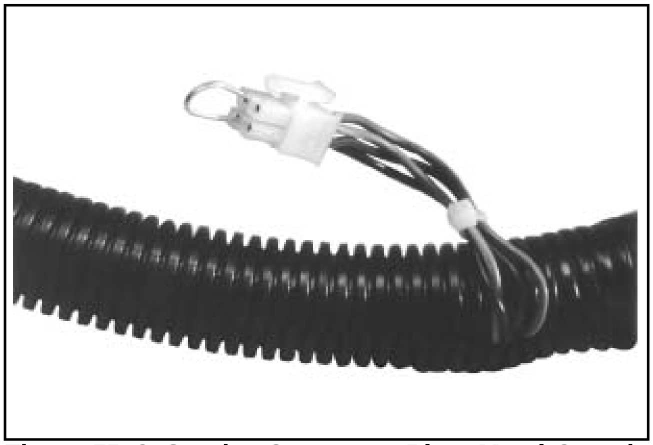


Figure 5B-8. Service Connector Plug, Metal-Cased ECU Harness.

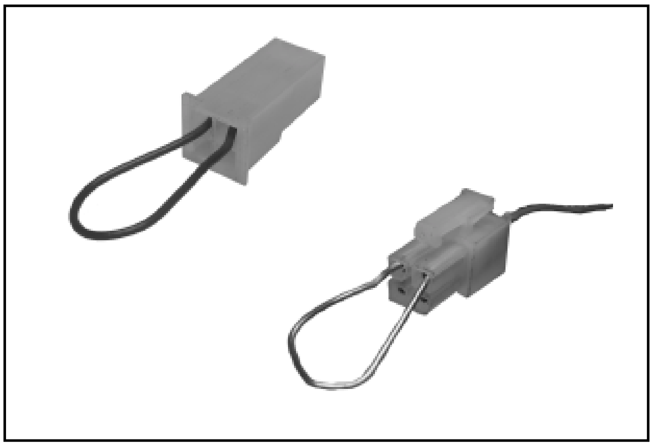


Figure 5B-9. Service Connector Plug, Plastic-Cased ECU Harness.

8. Hold throttle against idle speed stop screw, turn the ignition switch to "on" position (do not start engine), and observe the Malfunction Indicator Light (MIL).

   a. The light should blink on/off quickly for approximately 3 seconds and then go off and stay off, indicating the initialization procedure has been successful.

   b. If light stays on or blinking ceases prematurely, the procedure was unsuccessful and must be repeated. Possible causes for unsuccessful learning may be: 1) Movement occurred in either the TPS or throttle shaft during procedure, 2) Crankshaft movement/rotation was detected by the speed sensor during procedure, 3) Throttle plate position was out of learnable range (recheck the 1500 RPM idle speed adjustment), or 4) Problem with ECU or TPS.

9. When the initialization procedure has been successfully completed, turn off the key switch, remove the jumper wire or connector, and remove the rubber band from the throttle lever.

10. Disconnect negative (-) battery cable temporarily to clear all learned adjustments.

11. Reconnect the battery cable and all external loads. Readjust the idle speed to the equipment manufacturer's specified setting and recheck the high-speed, no-load RPM setting. Observe the overall performance.

5B

TPS Initialization Procedure
For "32 Pin" (MSE 1.1) Plastic-Cased ECU Only ("Auto-Learn" Initialization)

1. Check that the basic engine, all sensors, fuel, fuel pressure, and battery are good and functionally within specifications.

Important!

2. Remove/disconnect ALL external loads from the engine (belts, pumps, electric PTO clutch, alternator, rectifier-regulator, etc.).

3. Locate the service connector plug in the wiring harness. To initiate the TPS auto-learn function, connect a jumper wire from the TPS initialization pin #24 (violet wire) to the battery voltage pin (red wire), or use jumper plug (SPX Part No. **KO3217-9**). If using the PC-based diagnostic tool and software (Kohler Part No. **25 761 23-S**), go to "Special Tests" and follow the prompts to complete.

4. Start the engine and immediately observe the Malfunction Indicator Light (MIL). The light should start blinking 4 consecutive times every 2 seconds.

5. Remove the jumper wire or plug from the service connector plug in wiring harness.

6. Run the engine at full throttle (above 3000 RPM), to warm up the engine and initiate O_2 sensor function in "closed-loop" operation.

7. Watch the "MIL". When the light starts blinking rapidly, (5 blinks per second), move the throttle lever to the low idle speed position. Check and adjust the idle speed to **1500 RPM**, using a tachometer. The lamp should continue to blink rapidly for another 30 seconds before switching to a slow blink.

8. When the "MIL" blinks slowly, do not do anything but wait until the "MIL" shuts off. This indicates that this procedure has been completed successfully.

9. Shut off the engine.

   If the learn procedure was successfully completed, the external loads removed/ disconnected in Step 2 may be reconnected.

   If the procedure was unsuccessful see Steps a. and b. following.

   a. If during this procedure, the "MIL" goes back into blinking 4 consecutive blinks every 2 seconds, the engine and O_2 sensor have cooled down and out of "closed-loop" operation, prohibiting the learning from occurring. Repeat Steps 6-9.

   b. If during the procedure with the engine running, the "MIL" stays "on" continuously, for more than 15 seconds, turn off the ignition. Then initiate the fault code sequence, by doing three consecutive key-on/key-off cycles leaving the key "on" in the last sequence, (each key-on/key-off sequence must be less than 2.5 seconds long). The fault detected must be corrected before the "auto-learn" function can be re-initiated. The PC-based diagnostic tool and software may be used to read out the fault code and assist with the troubleshooting and repair.

Engine (Oil) Temperature Sensor

Figure 5B-10. Engine (Oil) Temperature Sensor.

General
The engine (oil) temperature sensor (Figure 5B-10) is used by the system to help determine fuel requirements for starting, (a cold engine needs more fuel than one at or near operating temperature). Mounted in the oil filter adapter housing, it has a temperature-sensitive resistor that extends into the oil flow. The resistance changes with oil temperature, altering the voltage sent to the ECU. Using a table stored in its memory, the ECU correlates the voltage drop to a specific temperature. Using the fuel delivery "maps", the ECU then knows how much fuel is required for starting at that temperature.

Service
The temperature sensor is a sealed, non-serviceable assembly. A faulty sensor must be replaced. If a blink code indicates a problem with the temperature sensor, it can be tested as follows.

1. Remove the oil temperature sensor from the adapter housing and cap or block the adapter hole.

2. Wipe sensor clean and allow it to reach room temperature (20°C, 68°F).

3. Unplug the main harness connector from the ECU.

4. With the sensor connected, check the oil temperature sensor circuit resistance. The value should be **2375-2625 Ω**. See chart on pages 5B.28, 5B.31, or 5B.32.

   "35 Pin" (MA 1.7) Metal-Cased ECU: Check between the #14 and #27 pin terminals.

"24 Pin" (MSE 1.0) Plastic-Cased ECU: Check between the #6 and #4 pin terminals.

"32 Pin" (MSE 1.1) Plastic-Cased ECU: Check between the #6 and #4 pin terminals.

5. Unplug the sensor connector and check sensor resistance separately. Resistance value should again be **2375-2625 Ω**.

   a. If the resistance is out of specifications, replace the temperature sensor.

   b. If it is within specifications, proceed to Step 6.

6. Check the temperature sensor circuits (input, ground) from the main harness connector to the corresponding terminal in the sensor plug for continuity, damage, etc.

   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuits #14 and #27.

   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuits #6 and #4.

   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuits #6 and #4.

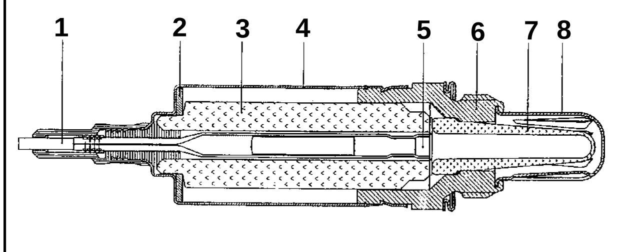
Oxygen Sensor

Figure 5B-11. Oxygen Sensor.

General

The oxygen sensor functions like a small battery, generating a voltage signal to the ECU, based upon the difference in oxygen content between the exhaust gas and the ambient air.

The tip of the sensor, protruding into the exhaust gas, is hollow (see cutaway Figure 5B-12). The outer portion of the tip is surrounded by the exhaust gas, with the inner portion exposed to the ambient air. When the oxygen concentration on one side of the tip is different than that of the other side, a voltage signal typically cycling between 0.2 and 1.0 volt is generated between the electrodes and sent to the ECU. The voltage signal tells the ECU if the engine is straying from the ideal 14.7:1 fuel mixture, and the ECU then adjusts the injector pulse accordingly.



1. Connection Cable
2. Disc Spring
3. Ceramic Support Tube
4. Protective Sleeve
5. Contact Element
6. Sensor Housing
7. Active Ceramic Sensor
8. Protective Tube

Figure 5B-12. Cutaway of Oxygen Sensor.

The oxygen sensor can function only after being heated by exhaust temperatures to a minimum of 375°C (709°F). A cold oxygen sensor will require approximately 1-2 minutes at moderate engine load to warm sufficiently to generate a voltage signal. Proper grounding is also critical. The oxygen sensor grounds through the metal shell, so a good, solid, unbroken ground path back through the exhaust system components, engine, and wiring harness is required. Any disruption or break in the ground circuit can affect the output signal and trigger misleading fault codes. Keep that in mind when doing any troubleshooting associated with the oxygen sensor. The oxygen sensor can also be contaminated by leaded fuel, certain RTV and/or other silicone compounds, carburetor cleaners, etc. Use only those products indicated as "O_2 Sensor Safe."

Service

Like the other sensors already discussed, the oxygen sensor is a non-serviceable component. Complete replacement is required if it is faulty. The sensor and wiring harness can be checked as follows.

NOTE: All tests should be conducted with a good quality, high-impedance, digital VOA meter for accurate results.

1. Oxygen sensor must be hot (minimum of 400°C, 725°F). Run engine for about 5 minutes. With the engine running, disconnect the oxygen sensor lead from the wiring harness. Set VOA meter for DC volts and connect the **red** lead to the disconnected sensor lead, and the **black** lead to the sensor shell. Check for a voltage reading between 0.2 v-1.0 v.

   a. If voltage is in the specified range, go to Step 2.

   b. If the voltage is not in the specified range, reconnect the oxygen sensor lead. With the lead connected, probe or connect the sensor connection with the red VOA meter lead. Attach the black VOA meter lead to a known good ground location. Start and run the engine at 3/4 throttle and note the voltage output.

      The reading should cycle between 0.2 v-1.0 v, which indicates the oxygen sensor is functioning normally and also the fuel delivery controlled by the ECU is within prescribed parameters. If the voltage readings show a steady decline, bump the governor lever to make the engine accelerate very quickly and check the reading again. If voltage momentarily increases and then again declines, without cycling, engine may be running lean due to incorrect TPS initialization. Shut off the engine, perform TPS initialization, and then repeat the test. If TPS initialization cannot be achieved, perform step c.

   c. Replace the oxygen sensor (page 5B.13). Run the engine long enough to bring the new sensor up to temperature and repeat the output test from step 1. The cycling voltage from 0.2 to 1.0 volt should be indicated.

2. Move the **black** voltmeter lead to the engine ground location and repeat the output test. The same voltage (0.2 v-1.0 v) should be indicated.

   a. If the same voltage reading exists, go on to Step 3.

   b. If the voltage output is no longer correct, a bad ground path exists between the sensor and the engine ground. Touch the black lead at various points, backtracking from the engine ground back toward the sensor, watching for a voltage change at each location. If the correct voltage reading reappears at some point, check for a problem (rust, corrosion, loose joint or connection) between that point and the previous checkpoint. For example, if the reading is too low at points on the crankcase, but correct voltage is indicated when the black lead is touched to the skin of the muffler, the flange joints at the exhaust ports become suspect.

3. With sensor still hot (minimum of 400°C, 752°F), switch meter to the Rx1K or Rx2K scale and check the resistance between the sensor lead and sensor case. It should be less than **2.0 KΩ**.

   a. If the resistance is less than **2.0 KΩ**, go to Step 4.

   b. If the resistance is greater than **2.0 KΩ**, the oxygen sensor is bad, replace it.

4. Allow the sensor to cool (less than 60°C, 140°F) and retest the resistance with the meter set on the Rx1M scale. With sensor cool, the resistance should be greater than **1.0 MΩ**.

   a. If the resistance is greater than **1.0 MΩ**, go to Step 5.

   b. If the resistance is less than **1.0 MΩ**, the sensor is bad, replace it.

5. With the oxygen sensor disconnected and engine not running, disconnect the main harness connector from the ECU and set the meter to the Rx1 scale. Check the circuit continuity as follows:

   “35 Pin” (MA 1.7) Metal-Cased ECU: Check for continuity from pin #9 of the ECU connector (see page 5B.28) to the shell of the oxygen sensor, and from pin #10 to the sensor connector terminal of the main harness. Both tests should indicate continuity.

   “24 Pin” (MSE 1.0) Plastic-Cased ECU: Check for continuity from pin #15 of the ECU connector (see page 5B.31) to the shell of the oxygen sensor, and from pin #11 to the sensor connector terminal of the main harness. Both tests should indicate continuity.

   “32 Pin” (MSE 1.1) Plastic Cased ECU: Check for continuity from pin #19 of the ECU connector (see page 5B.32) to the shell of the oxygen sensor, and from pin #20 to the sensor terminal of the main harness. Both tests should indicate continuity.

   a. If there is no continuity displayed in either of the tests, check the harness circuit for breaks or damage, and the connections for poor contact, moisture, or corrosion. If no continuity was found in the first test, also check for a poor/broken ground path back through the exhaust system, engine, and mounting (sensor is grounded through its shell).

   b. If continuity is indicated, go to step 6.

6. With the key switch in the ''on/run'' position, using a high impedance voltmeter, check the voltage from the wiring harness oxygen sensor connector to the engine ground location. Look for a steady voltage from **350-550 mv (0.35-0.55 v)**.

   a. If voltage reading is not as specified, move the black voltmeter lead to the negative post of the battery, to be certain of a good ground. If the voltage is still not correct, the ECU is probably bad.

   b. If voltage readings are correct, clear the fault codes and run the engine to check if any fault codes reappear.

To Replace Oxygen Sensor

1. Disconnect the oxygen sensor connector from wiring harness.

2. Loosen and remove the oxygen sensor from the exhaust manifold/muffler assembly.

3. Apply anti-seize compound sparingly to threads of new oxygen sensor, if none already exists. **DO NOT** get any on the tip as it will contaminate the sensor. Install sensor and torque to **50-60 N·m (37-44 ft. lb.)**.

4. Reconnect the lead to wiring harness connector. Make sure it can not contact hot surfaces, moving parts, etc.

5. Test run the engine.

Electrical Relay

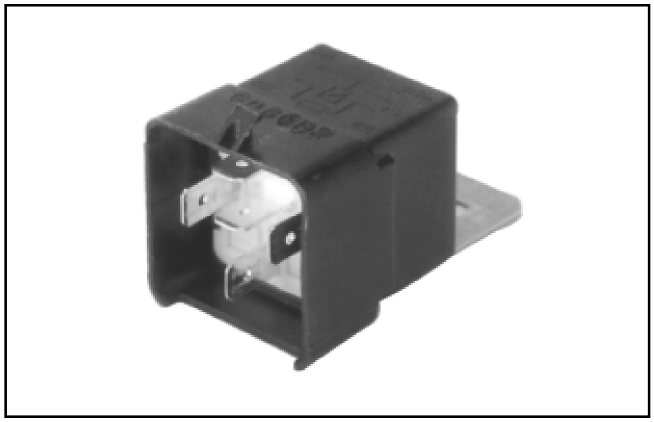


Figure 5B-13. Electrical Relay.

General

The electrical relay is used to supply power to the injectors, coils, and fuel pump. When the key switch is turned "on" and all safety switch requirements met, the relay provides 12 volts to the fuel pump circuit, injectors, and ignition coils. The fuel pump circuit is continuously grounded, so the pump is immediately activated and pressurizes the system. Activation of the ignition coils and injectors is controlled by the ECU, which grounds their respective circuits at the proper times.

Service

A malfunctioning relay can result in starting or operating difficulties. The relay and related wiring can be tested as follows.

1. Disconnect the relay connector plug from the relay.

2. Connect black lead of VOA meter to a chassis ground location. Connect red lead to the #86 terminal in relay connector (see Figure 5B-14). Set meter to test resistance (Rx1). Turn ignition switch from **"off"** to **"on"**. Meter should indicate continuity (ground circuit is completed) for 1 to 3 seconds. Turn key switch back off.

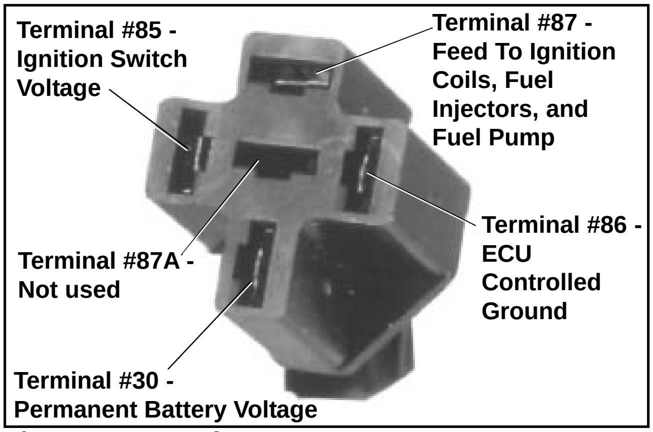


Figure 5B-14. Relay Connector.

a. Clean the connection and check wiring if circuit was not completed.

3. Set meter for DC voltage. Touch red tester lead to the #30 terminal in relay connector. A reading of **12 volts** should be indicated at all times.

4. Connect red lead of meter to the #85 terminal in relay connector. Turn key switch to the "on" position. Battery voltage should be present.

   a. No voltage present indicates a problem in the wiring or at the connector.

   b. If voltage is present, the wiring to the connector is good. Turn ignition switch **"off"** and proceed to test 5 to test the relay.

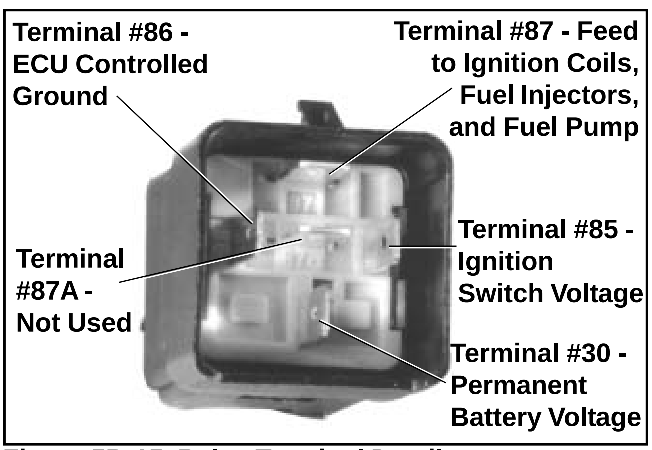


Figure 5B-15. Relay Terminal Details.

5. Connect an ohmmeter (Rx1 scale) between the #85 and #86 terminals in the relay. There should be continuity. See Figure 5B-15.

6. Attach ohmmeter leads to the #30 and #87 terminals in relay. Initially, there should be no continuity. Using a 12 volt power supply, connect the positive (+) lead to the #85 terminal and touch the negative (-) lead to the #86 terminal. When 12 volts is applied, the relay should activate and continuity should exist (circuit made) between the #30 and #87 terminals. Repeat the test several times. If, at any time the relay fails to activate the circuit, replace the relay.

Fuel Injectors

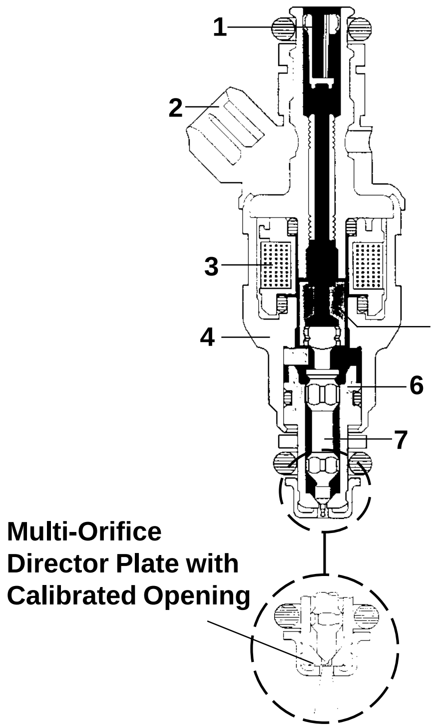
Figure 5B-16. Style 1 Fuel Injector.

Figure 5B-17. Style 2 Fuel Injector.

General

The fuel injectors mount into the intake manifold, and the fuel rail attaches to them at the top end. Replaceable O-Rings on both ends of the injector prevent external fuel leakage and also insulate it from heat and vibration. A special clip connects each injector to the fuel rail, retaining it in place.

When the key switch is on and the relay is closed, the fuel rail is pressurized, and voltage is present at the injector. At the proper instant, the ECU completes the ground circuit, energizing the injector. The valve needle in the injector is opened electromagnetically, and the pressure in the fuel rail forces fuel down through the inside. The "director plate" at the tip of the injector (see inset) contains a series of calibrated openings which directs the fuel into the manifold in a cone-shaped spray pattern.



1. Filter strainer in fuel supply
2. Electrical connection
3. Solenoid winding
4. Valve housing
5. Armature
6. Valve body
7. Valve needle

Figure 5B-18. Fuel Injector Details.

The injector is opened and closed once for each crankshaft revolution, however only one-half the total amount of fuel needed for one firing is injected during each opening. The amount of fuel injected is controlled by the ECU and determined by the length of time the valve needle is held open, also referred to as the "injection duration" or "pulse width". It may vary in length from 1.5-8 milliseconds depending on the speed and load requirements of the engine.

Service

Injector problems typically fall into three general categories: electrical, dirty/clogged, or leakage. An electrical problem usually causes one or both of the injectors to stop functioning. Several methods may be used to check if the injectors are operating.

1. With the engine running at idle, feel for operational vibration, indicating that they are opening and closing.

2. When temperatures prohibit touching, listen for a buzzing or clicking sound with a screwdriver or mechanic's stethoscope (see Figure 5B-19).

Figure 5B-19. Checking Injectors.

3. Disconnect the electrical connector from an injector and listen for a change in idle performance (only running on one cylinder) or a change in injector noise or vibration.

If an injector is not operating, it can indicate either a bad injector, or a wiring/electrical connection problem. Check as follows:

NOTE: **Do not** apply voltage to the fuel injector(s). Excessive voltage will burn out the injector(s). **Do not** ground the injector(s) with the ignition **"on"**. Injector(s) will open/turn on if relay is energized.

1. Disconnect the electrical connector from both injectors. Plug the 12 volt test light (SPX Part No. **KO3217-6**) in one connector.

5B

Figure 5B-20. Volt Test Light.

2. Make sure all safety switch requirements are met. Crank the engine and check for flashing of test light. Repeat test at other connector.

   a. If flashing occurs, use an ohmmeter (Rx1 scale) and check the resistance of each injector across the two terminals. Proper resistance is **12-20 Ω**. If injector resistance is correct, check whether the connector and injector terminals are making a good connection. If the resistance is not correct, replace the injector following steps 1-8 and 13-16 below.

   b. If no flashing occurs, reattach connectors to both injectors. Disconnect the main harness connector from the ECU and the connector from the relay. Set the ohmmeter to the Rx1 scale and check the injector circuit resistance as follows:

      "35 Pin" (MA 1.7) Metal-Cased ECU: Check the resistance between the relay terminal #87 and pin #35 in main connector. Resistance should be **4-15 Ω**.

      "24 Pin" (MSE 1.0) Plastic-Cased ECU: Check the resistance between relay terminal #87 and pin #16 in main connector. Then check resistance between relay terminal #87 and pin #17. Resistance should be **4-15 Ω** for each circuit.

      "32 Pin" (MSE 1.1) Plastic-Cased ECU: Check the resistance between relay terminal #87 and pin #14 in the main connector. Then check the resistance between relay terminal #87 and pin #15. Resistance should be **4-15 Ω** for each circuit.

   Check all electrical connections, connectors, and wiring harness leads if resistance is incorrect.

Injector leakage is very unlikely, but in those rare instances it can be internal (past the tip of the valve needle), or external (weeping around the injector body). See Figure 5B-21. The loss of system pressure from the leakage can cause hot restart problems and longer cranking times. To check for leakage it will be necessary to remove the blower housing, which may involve removing the engine from the unit.

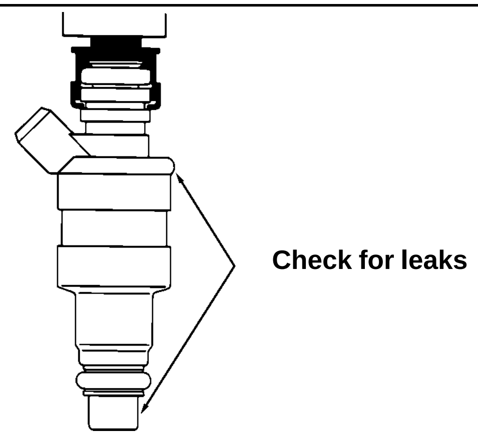


Figure 5B-21. Injector Inspection Points.

1. Engine must be cool. Depressurize fuel system through test valve in fuel rail.

2. Disconnect spark plug leads from spark plugs.

3. Remove the air cleaner outer cover, inner wing nut, element cover and air cleaner element/ precleaner. Service air cleaner components as required.

4. Remove the two screws securing the air cleaner base to throttle body manifold. Remove the air cleaner base to permit access to the injectors. Check condition of air cleaner base gasket, replace if necessary.

5. Remove the flywheel screen if it overlaps the blower housing.

6. If the engine has a radiator-type oil cooler mounted to the blower housing, remove the two oil cooler mounting screws.

7. Remove the blower housing mounting screws. Note the location of the plated (silver) screw attaching the rectifier-regulator ground lead. Remove the blower housing.

8. Thoroughly clean the area around and including the throttle body/manifold and the injectors.

9. Disconnect the throttle linkage and damper spring from the throttle lever. Disconnect the TPS lead from the harness.

10. Remove the manifold mounting bolts and separate the throttle body/manifold from the engine leaving the TPS, fuel rail, air baffle, injectors and line connections intact. Discard the old gaskets.

11. Position the manifold assembly over an appropriate container and turn the key switch **"on"** to activate the fuel pump and pressurize the system. Do not turn switch to **"start"** position.

12. If either injector exhibits leakage of more than two to four drops per minute from the tip, or shows any sign of leakage around the outer shell, turn the ignition switch off and replace injector as follows.

13. Depressurize the fuel system following the procedure in the fuel warning on page 5B.2. Remove the two fuel rail mounting screws.

14. Clean any dirt accumulation from the sealing/ mounting area of the faulty injector(s) and disconnect the electrical connector(s).

15. Pull the retaining clip off the top of the injector(s) and remove from manifold.

16. Reverse the appropriate procedures to install the new injector(s) and reassemble the engine. Use new O-Rings any time an injector is removed (new replacement injectors include new O-Rings). Lubricate O-Rings lightly with oil. Torque the fuel rail and blower housing mounting screws to **3.9 N·m (35 in. lb.)**, and the intake manifold and air cleaner mounting screws to **9.9 N·m (88 in. lb.)**.

Injector problems due to dirt or clogging are generally unlikely, due to the design of the injectors, the high fuel pressure, and the detergent additives in the gasoline. Symptoms that could be caused by dirty/clogged injectors include rough idle, hesitation/stumble during acceleration, or triggering of fault codes related to fuel delivery. Injector clogging is usually caused by a buildup of deposits on the director plate, restricting the flow of fuel, resulting in a poor spray pattern. Some contributing factors to injector clogging include higher than normal operating temperatures, short operating intervals, and dirty, incorrect, or poor quality fuel. Cleaning of clogged injectors is not recommended; they should be replaced. Additives and higher grades of fuel can be used as a preventative measure if clogging has been a problem.

Ignition System

General

A high voltage, solid state, battery ignition system is used with the EFI system. The ECU controls the ignition output and timing through transistorized control of the primary current delivered to the coils. Based on input from the speed sensor, the ECU determines the correct firing point for the speed at which the engine is running. At the proper instant, it releases the flow of primary current to the coil. The primary current induces high voltage in the coil secondary, which is then delivered to the spark plug. Each coil fires every revolution, but every other spark is "wasted."

Service

Except for removing the spark plug lead by unscrewing it from the secondary tower (see Figure 5B-22), no coil servicing is possible. If a coil is determined to be faulty, replacement is necessary. An ohmmeter may be used to test the wiring and coil windings.

Figure 5B-22. Ignition Coil.

NOTE: Do not ground the coils with the ignition **"on,"** as they may overheat or spark.

Testing

1. Disconnect the main harness connector from ECU.

   "35 Pin" (MA 1.7) Metal-Cased ECU: Locate pins #1 and #19 in the 35 pin connector. See page 5B.28.

"24 Pin" (MSE 1.0) Plastic-Cased ECU: Locate pins #22 and #23 in the 24 pin connector. See page 5B.31.

"32 Pin" (MSE 1.1) Plastic Cased ECU: Locate pins #30 and #31 in the 32 pin connector. See page 5B.32.

2. Disconnect connector from relay and locate terminal #87 in connector.

3. Using an ohmmeter set on the Rx1 scale, check the resistance in circuits as follows:

   "35 Pin" (MA 1.7) Metal-Cased ECU: Check between terminal #87 and pin #1 for coil #1. Repeat the test between terminal #87 and pin #19 for coil #2.

   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Check between terminal #87 and pin #22 for coil #1. Repeat the test between terminal #87 and pin #23 for coil #2.

   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Check between terminal #87 and pin #30 for coil #1. Repeat the test between terminal #87 and pin #31 for coil #2.

   A reading of **1.8-4.0 Ω** in each test indicates that the wiring and coil primary circuits are OK.

   a. If reading(s) are not within specified range, check and clean connections and retest.

   b. If reading(s) are still not within the specified range, test the coils separately from main harness as follows:

      1. Disconnect the red and black primary leads from the coil terminals.

      2. Connect an ohmmeter set on the Rx1 scale to the primary terminals. Primary resistance should be **1.8-2.5 Ω**.

      3. Disconnect the secondary lead from the spark plug. Connect an ohmmeter set on the Rx10K scale between the spark plug boot terminal and the red primary terminal. Secondary resistance should be **13,000-17,500 Ω**.

      4. If the secondary resistance is not within the specified range, unscrew the spark plug lead nut from the coil secondary tower and remove the plug lead. Repeat step b. 3, testing from the secondary tower terminal to the red primary terminal. If resistance is now correct, the coil is good, but the spark plug lead is faulty, replace the lead. If step b. 2 resistance was incorrect and/or the secondary resistance is still incorrect, the coil is faulty and needs to be replaced.

Spark Plugs

EFI engines are equipped with Champion® RC12YC (Kohler Part No. **12 132 02-S**) resistor style spark plugs. Equivalent alternate brand plugs can also be used, but must be a resistor style plug or permanent damage to the ECU will occur in addition to affecting operation. Proper spark plug gap is **0.76 mm (0.030 in.)**.

Wiring Harness

The wiring harness used in the EFI system connects the electrical components, providing current and ground paths for the system to operate. All input and output signaling occurs through a special all weather connector that attaches and locks to the ECU (see Figures 5B-23, 5B-24, and 5B-25).

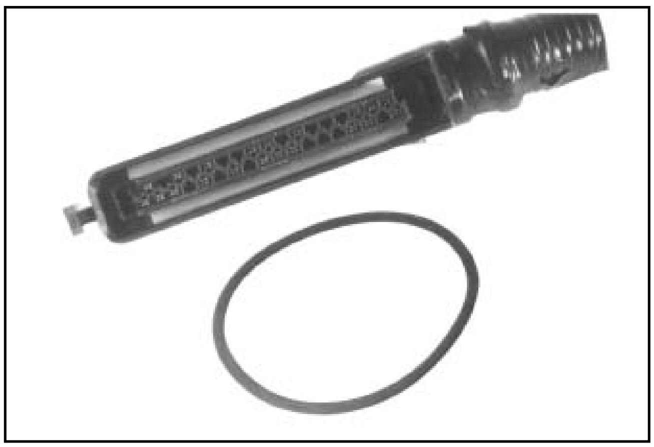


Figure 5B-23. "35 Pin" (MA 1.7) Metal-Cased ECU Connector and O-Ring.

Figure 5B-24. "24 Pin" (MSE 1.0) Plastic-Cased ECU Connector.

Figure 5B-25. "32 Pin" (MSE 1.1) Plastic-Cased ECU Connector.

The condition of the wiring, connectors, and terminal connections is essential to system function and performance. Corrosion, moisture, and poor connections are more likely the cause of operating problems and system errors than an actual component. Refer to the "Troubleshooting – Electrical" section for additional information.

Battery Charging System

EFI engines are equipped with either a 15 or 25 amp charging system to accommodate the combined electrical demands of the ignition system and the specific application. Charging system troubleshooting information is provided in Section 8.

Fuel Components

Fuel Pump

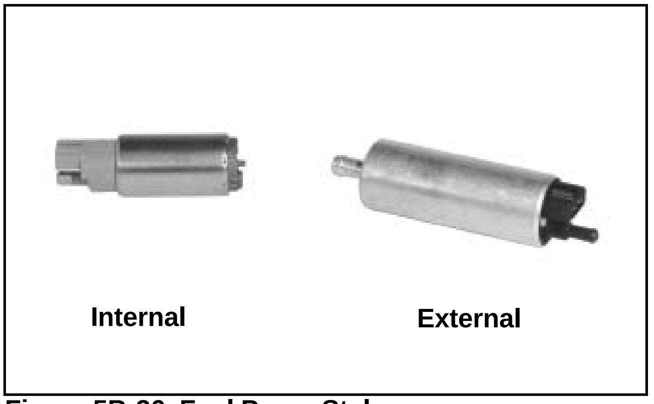


Figure 5B-26. Fuel Pump Styles.

General

An electric fuel pump is used to transfer fuel in the EFI system. Depending on the application, the pump may be inside the fuel tank, or in the fuel line near the tank. The pumps are rated for a minimum output of 25 liters per hour at 39 psi. The pumps have an internal 60-micron filter. In addition, the in-tank style pumps will have a pre-filter attached to the inlet. In-line pump systems may also have a filter ahead of the pump on the pick-up/low pressure side. The final filter is covered separately on page 5B.22.

When the key switch is turned **"on"** and all safety switch requirements are met, the ECU, through the relay, activates the fuel pump, which pressurizes the system for start-up. If the key switch is not promptly turned to the "start" position, the engine fails to start, or the engine is stopped with the key switch "on" (as in the case of an accident), the ECU switches off the pump preventing the continued delivery of fuel. In this situation, the MIL will go on, but it will go back off after 4 cranking revolutions if system function is OK. Once the engine is running, the fuel pump remains on.

Service

The fuel pumps are non-serviceable and must be replaced if determined to be faulty. If a fuel delivery problem is suspected, make certain the pump is being activated through the relay, all electrical connections are properly secured, the fuses are good, and a minimum of 7.0 volts is being supplied. If during cranking, voltage drops below 7.0 volts, a reduction of fuel pressure may occur resulting in a lean starting condition. If required, testing of the fuel pump and relay may be conducted.

1. Connect the black hose of Kohler pressure tester (SPX Part No. **KO3217-4**), to the test valve in the fuel rail. Route the clear hose into a portable gasoline container or the equipment fuel tank.

2. Turn on the key switch to activate the pump and check the system pressure on the gauge. If system pressure of **39 psi ± 3** is observed, the relay, fuel pump, and regulator are working properly. Turn the key switch off and depress the valve button on the tester to relieve the system pressure.

   a. If the pressure is too high, and the regulator is outside the tank (just down line from the pump), check that the return line from the regulator to the tank is not kinked or blocked. If the return line is good, replace the regulator (see ''Regulator Service'' on page 5B.21).

   b. If the pressure is too low, install in-line ''T'' (SPX Part No. **KO3217-8**) between the pump and regulator and retest the pressure at that point. If it is too low there also, replace the fuel pump.

3. If the pump did not activate (step 2), disconnect the plug from the fuel pump. Connect a DC voltmeter across the terminals in the plug, turn on the key switch and observe if a minimum of 7 volts is present. If voltage is between 7 and 14, turn key switch off and connect an ohmmeter between the terminals on the pump to check for continuity.

   a. If there was no continuity between the pump terminals, replace the fuel pump.

   b. If the voltage was below 7, test the wiring harness and relay as covered in the ''Electrical Relay'' section.

4. If voltage at the plug was good, and there was continuity across the pump terminals, reconnect the plug to the pump, making sure you have a good connection. Turn on the key switch and listen for the pump to activate.

   a. If the pump starts, repeat steps 1 and 2 to verify correct pressure.

   b. If the pump still does not operate, replace it.

Fuel Pressure Regulator

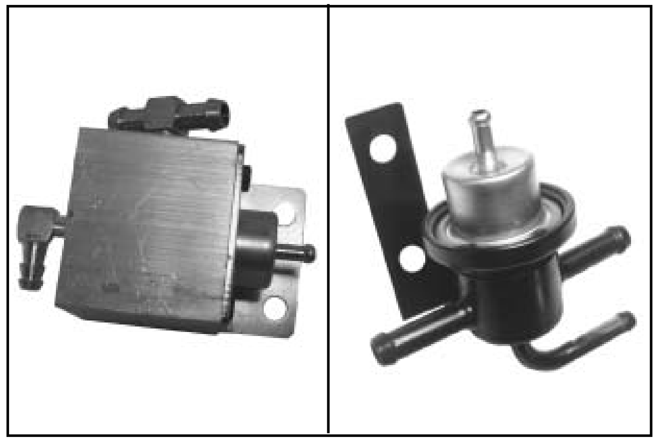


Figure 5B-27. External Fuel Pressure Regulators with Base.

Figure 5B-28. Internal Fuel Pressure Regulator.

General

The fuel pressure regulator assembly maintains the required operating system pressure of **39 psi ± 3**. A rubber-fiber diaphragm (see Figure 5B-29) divides the regulator into two separate sections; the fuel chamber and the pressure regulating chamber. The pressure regulating spring presses against the valve holder (part of the diaphragm), pressing the valve against the valve seat. The combination of atmospheric pressure and regulating spring tension equals the desired operating pressure. Any time the fuel pressure against the bottom of the diaphragm exceeds the desired (top) pressure, the valve opens, relieving the excess pressure, returning the excess fuel back to the tank.

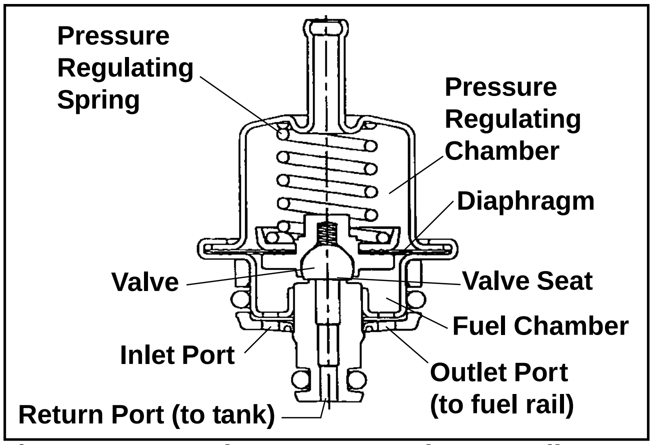


Figure 5B-29. Fuel Pressure Regulator Details.

Service
Depending on the application, the regulator may be located in the fuel tank along with the fuel pump, or outside the tank just down line from the pump. The regulator is a sealed, non-serviceable assembly. If it is faulty, it must be separated from the base/holder assembly and replaced as follows.

1. Shut engine off, make sure engine is cool, and disconnect the negative (-) battery cable.

2. Depressurize fuel system through test valve in fuel rail (see fuel warning on page 5B.2).

3. Access the regulator assembly as required and clean any dirt or foreign material away from the area.

4. **External Regulator -**
   Based upon the style of regulator used: See Figure 5B-30.

   a. Remove the two screws securing the mounting bracket to the regulator housing. Remove the O-Ring and pull the regulator out of the housing.

   b. Remove the snap ring and remove regulator from base/holder.

   Internal (In-Tank) Regulator -
   Remove the three screws securing the retaining ring and regulator in the base/holder assembly. Grasp and pull the regulator out of the base/holder. See Figure 5B-31.

Figure 5B-30. External Regulators and Base/Holders.

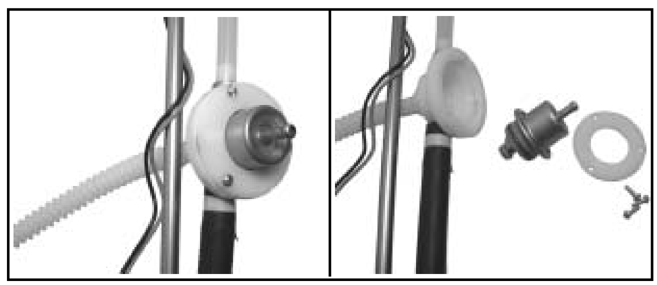


Figure 5B-31. Internal Regulator and Base/Holder.

5. Always use new O-Rings and hose clamps when installing a regulator. A new replacement regulator will have new O-Rings already installed. Lubricate the O-Rings (external regulator) with light grease or oil.

6. a. Install the new regulator by carefully pushing and rotating it slightly into the base or housing.

   b. External Regulators with Square Base Housing Only; Install a new O-Ring between the regulator and the mounting bracket. Set the mounting bracket into position.

   c. Secure the regulator in base with the original retaining ring or screws. Be careful not to dent or damage the body of the regulator as operating performance can be affected.

7. Reassemble any parts removed in step 3.

8. Reconnect the negative (-) battery cable.

9. Recheck regulated system pressure at fuel rail test valve.

Fuel Filter

EFI engines use a high-volume, high-pressure, 10-15 micron, in-line fuel filter.

Figure 5B-32. In-Line Fuel Filter.

Service
Fuel filter replacement is recommended every **1500 hours** of operation or more frequently under extremely dusty or dirty conditions. Use only the specified filter, and install it according to the directional arrows. **Do not** use a substitute filter as operating performance and safety can be affected. Relieve system pressure through the safety valve in the fuel rail before servicing.

Fuel Rail

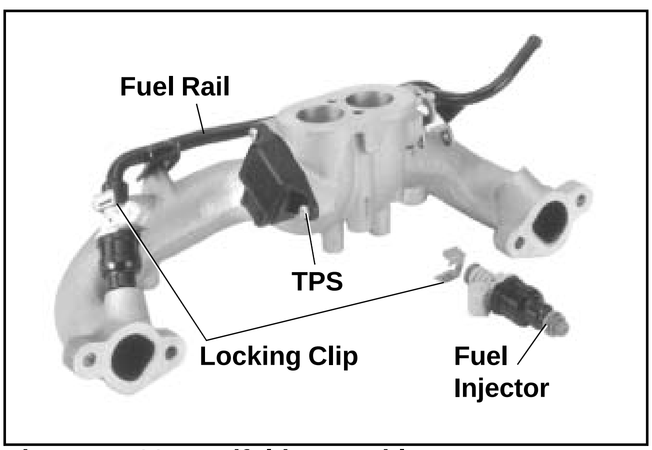


Figure 5B-33. Manifold Assembly.

General
The fuel rail is a formed tube assembly that feeds fuel to the top of the injectors. The tops of the injectors fit into formed cups in the fuel rail. When the rail is fastened to the manifold, the injectors are locked into place. A small retaining clip provides a secondary lock. Incorporated into the fuel rail is a pressure relief/test valve for testing operating pressure or relieving fuel system pressure for servicing. The fuel supply line is attached to the barbed end of the fuel rail with an Oetiker hose clamp.

Service
The fuel rail is mounted to the throttle body/intake manifold. It can be detached by removing the two mounting screws and the injector retaining clips. Thoroughly clean the area around all joints prior to any disassembly. No specific servicing is required unless operating conditions indicate that it needs internal cleaning or replacement.

Fuel Line

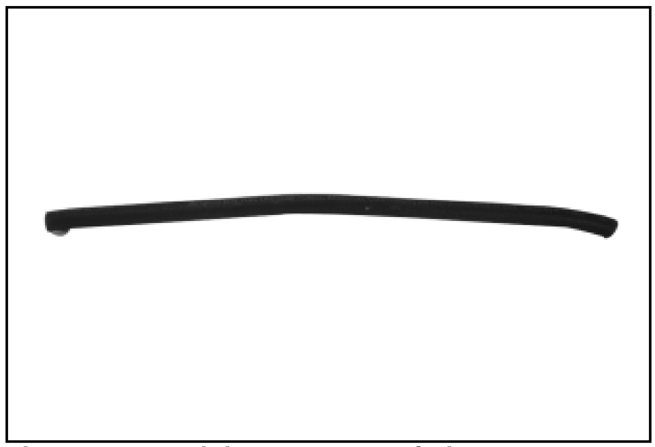


Figure 5B-34. High Pressure Fuel Line.

General
High-pressure fuel line with an SAE R9 rating is required for safe and reliable operation, due to the higher operating pressure of the EFI system. If hose replacement is necessary, order Fuel Line Service Kit, Part No. **24 353 42-S** (containing 5 ft. of high-pressure hose and 10 Oetiker clamps), or use only the type specified. Special Oetiker clamps (Kohler Part No. **24 237 05-S**) are used on all fuel line connections to prevent tampering and safety hazards with the high fuel pressure. The old clamp must be cut to open a connection, so replacement is necessary each time. Pliers (SPX Part No. KO3217-5) is used to crimp the replacement clamps.

***CAUTION:** Standard fuel line is not compatible and **must not** be used! Use **only** Oetiker clamps (Kohler Part No. 24 237 05-S) on fuel line connections.*

Throttle Body/Intake Manifold Assembly

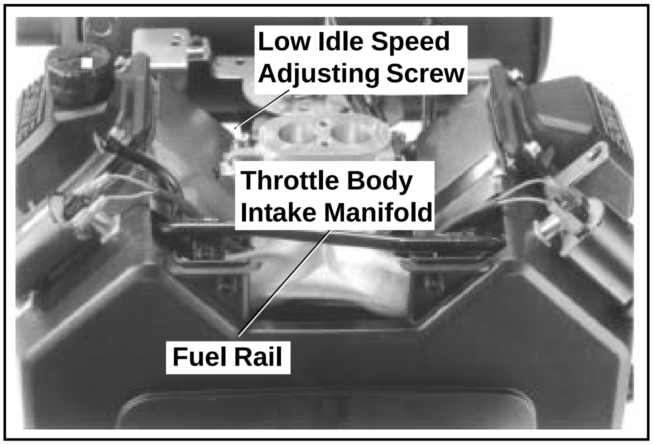


Figure 5B-35. Upper Intake Manifold.

General

The EFI engines have no carburetor, so the throttle function (regulate incoming combustion airflow) is incorporated in the intake manifold assembly. The manifold consists of a one-piece aluminum casting which also provides mounting for the fuel injectors, throttle position sensor, fuel rail, air baffle, idle speed screw, and air cleaner assembly.

Service

The throttle body/intake manifold is serviced as an assembly, with the throttle shaft, throttle plates, and idle speed adjusting screw installed. The throttle shaft rotates on needle bearings (non-serviceable), capped with rubber seals to prevent air leaks.

Idle Speed Adjustment (RPM)

General

The idle speed is the only adjustment that may be performed on the EFI system. The standard idle speed setting for EFI engines is 1500 RPM, but certain applications might require a different setting. Check the equipment manufacturer's recommendation.

For starting and warm up, the ECU will adjust the fuel and ignition timing, based upon ambient temperature, engine temperature, and loads present. In cold conditions, the idle speed will probably be higher than normal for a few moments. Under other conditions, the idle speed may actually start lower than normal, but gradually increase to the established setting as operation continues. **Do not** attempt to circumvent this warm up period, or readjust the idle speed during this time. The engine must be completely warmed up for accurate idle speed adjustment.

Adjustment Procedure

1. Make sure there are no fault codes present in the ECU memory.

2. Start the engine and allow it to **fully warm up** and establish closed looped operation (approximately 5-10 min.).

3. Place the throttle control in the "idle/slow" position and check the idle speed with a tachometer. Turn the idle speed screw in or out as required to obtain **1500 RPM**, or the idle speed specified by the equipment manufacturer.

4. The low idle speed adjustment can affect the high speed setting. Move the throttle control to the full throttle position and check the high speed. Adjust as necessary to 3750 RPM (no load), or the speed specified by the equipment manufacturer.

Idle Speed Screw Dampening Spring

A small dampening spring (Kohler Part No. **24 089 42-S**) is attached to the end of the idle speed screw of some EFI engines to help stabilize no load operating speeds. See Figure 5B-36.

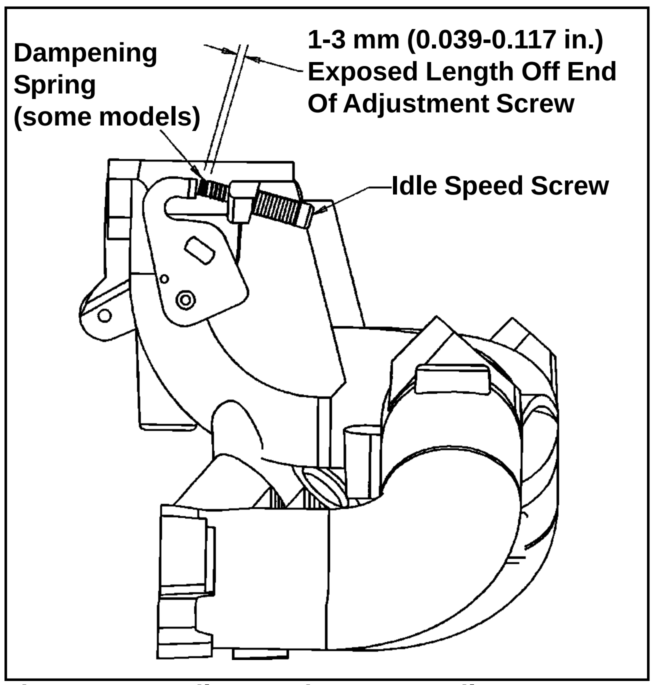


Figure 5B-36. Idle Speed Screw Details.

The idle speed adjustment procedure remains the same for engines with or without a dampening spring. Typically, no periodic servicing is necessary in this area. If however, removal/replacement of the dampening spring is required, reinstall it as follows:

1. Thread the spring onto the end of idle screw leaving **1-3 mm (0.039-0.117 in.)** of the spring extending beyond the end of the idle speed screw.

2. Secure spring onto the screw with a small amount of Permabond™ LM-737 or equivalent Loctite® adhesive. Do not get any adhesive on free coils of spring.

3. Start the engine and recheck the idle speed settings, after sufficient warm up. Readjust as required.

Initial Governor Adjustment

The initial governor adjustment is especially critical on EFI engines because of the accuracy and sensitivity of the electronic control system. Incorrect adjustment can result in overspeed, loss of power, lack of response, or inadequate load compensation. If you encounter any of these symptoms and suspect them to be related to the governor setting, the following should be used to check and/or adjust the governor and throttle linkage.

If the governor/throttle components are all intact, but you think there may be a problem with the adjustment, follow Procedure A to check the setting. If the governor lever was loosened or removed, go immediately to Procedure B to perform the initial adjustment.

A. Checking the Initial Adjustment

1. Unsnap the plastic linkage bushing attaching the throttle linkage to the governor lever. See Figure 5B-37. Unhook the damper spring from the lever, separate the linkage from the bushing, and remove the bushing from the lever. Mark the hole position and unhook the governor spring from the governor lever.

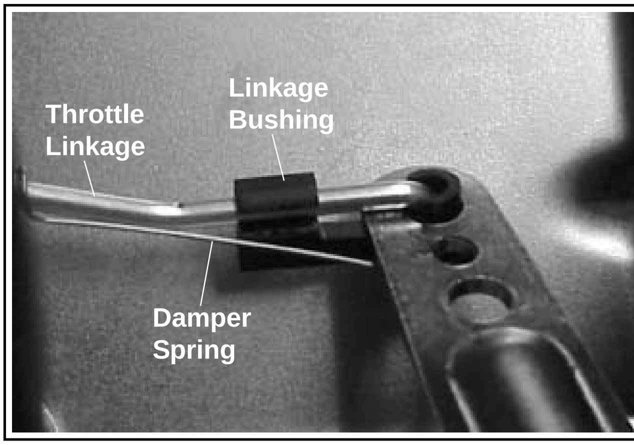


Figure 5B-37. Throttle Linkage/Governor Lever Connection.

2. Check if the engine has a high-speed throttle stop screw installed in the manifold casting boss. See Figure 5B-38.

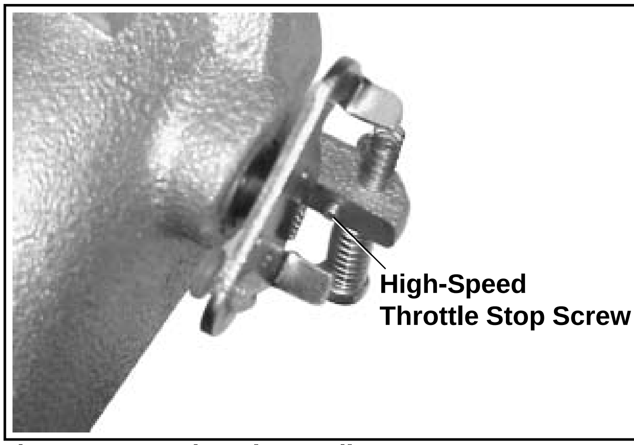


Figure 5B-38. Throttle Details.

   a. On engines without a stop screw, pivot the throttle shaft and plate assembly into the “Full Throttle” position. Insert a **1.52 mm (0.060 in.)** feeler gauge between the rear tang of the throttle shaft plate and the underside of the manifold boss. Use a locking pliers (needle nose works best) to temporarily clamp the parts in this position. See Figure 5B-39.

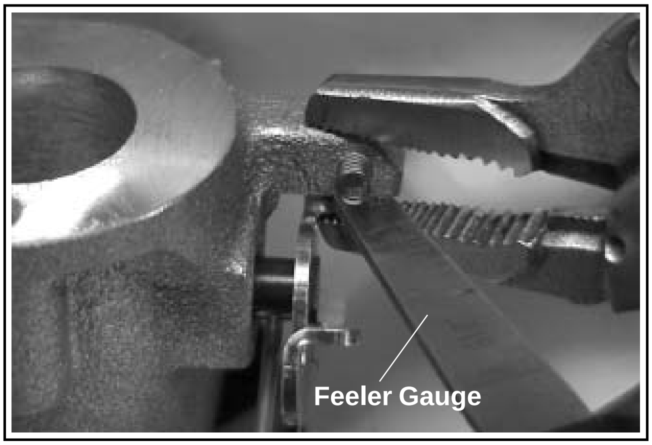


Figure 5B-39. Inserting Feeler Gauge (Engines Without Stop Screw).

b. On engines with a stop screw, pivot the throttle shaft and plate into the "Full Throttle" position, so the tang of the throttle shaft plate is against the end of the high-speed stop screw. See Figure 5B-38. Temporarily clamp in this position.

3. Rotate the governor lever and shaft counterclockwise until it stops. Use only enough pressure to hold it in that position.

4. Check how the end of the throttle linkage aligns with the bushing hole in the governor lever. See Figure 5B-40. It should fall in the center of the hole. If it doesn't, perform the adjustment procedure as follows.

Figure 5B-40. Throttle Link in Center of Hole.

B. Setting the Initial Adjustment

1. Check the split where the clamping screw goes through the governor lever. See Figure 5B-41. There should be a gap of at least 1/32". If the tips are touching and there is no gap present, the lever should be replaced.

If not already installed, position the governor lever on the cross shaft, but leave the clamping screw loose.

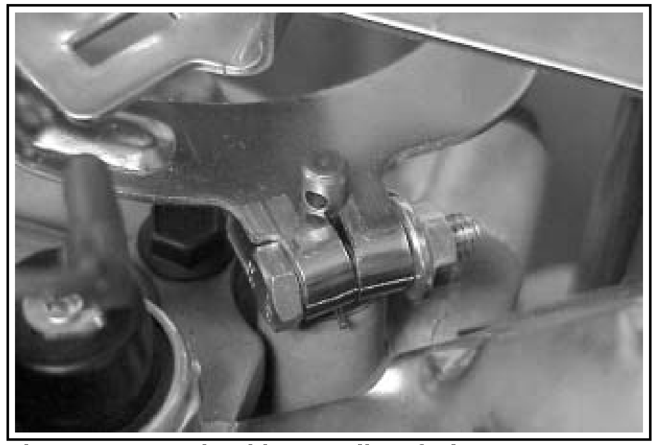


Figure 5B-41. Checking "Split" of Clamp.

2. Follow the instructions in Step 2 of "Checking the Initial Adjustment," then reattach the throttle linkage to the governor lever with the bushing clip. It is not necessary to reattach the damper or governor springs at this time.

3. Insert a nail into the hole in the top of the cross shaft. Using light pressure, rotate the governor shaft counterclockwise as far as it will turn, then torque the hex. nut on the clamping screw to **9.9 N·m (88 in. lb.)**. See Figure 5B-42. Make sure that the governor arm has not twisted up or down after the nut has been tightened.

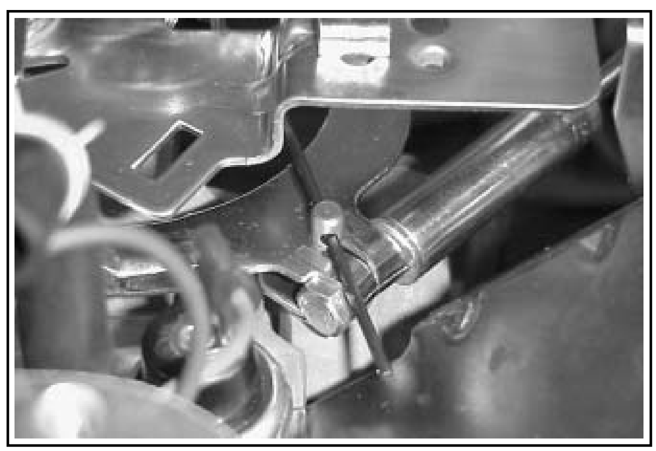


Figure 5B-42. Adjusting Governor Shaft.

4. Verify that the governor has been set correctly. With the linkage still retained in the "Full Throttle" position (Step 2), unsnap the bushing clip, separate the linkage from the bushing, and remove the bushing from the lever. Follow Steps 3 and 4 in ''Checking the Initial Adjustment''.

5. Reconnect the dampening spring into its governor lever hole from the bottom. Reinstall the bushing and reattach the throttle linkage. See Figure 5B-37. Reattach the governor spring in the marked hole.

6. Start the engine and allow it to fully warm up and establish closed loop operation (approximately 5-10 min.). Check the speed settings and adjust as necessary, first the low idle speed, and then the high speed setting.

Troubleshooting

General

When troubleshooting a problem on an engine with EFI, basic engine operating problems must be eliminated first before faulting the EFI system components. What appears to be an EFI problem could be something as simple as a fuel tank with debris in the bottom or a plugged vent. Be sure the engine is in good mechanical operating condition and all other systems are functional before attempting to troubleshoot the EFI system.

Troubleshooting Guide

Engine starts hard or fails to start when cold

1. Fuel pump not running
2. Faulty spark plugs
3. Old/stale fuel
4. Incorrect fuel pressure
5. Speed sensor loose or faulty
6. TPS offset incorrect (initialization)
7. TPS faulty
8. Engine temperature sensor faulty
9. Faulty coils
10. Low system voltage
11. Faulty injectors

Engine starts hard or fails to start when hot

1. Faulty spark plugs
2. Fuel pump not running
3. Fuel pressure low
4. Insufficient fuel delivery
5. TPS offset incorrect (Initialization)
6. Speed sensor loose or faulty
7. TPS faulty
8. Engine temperature sensor faulty
9. Faulty injectors

Engine stalls or idles roughly (cold or warm)

1. Faulty spark plugs
2. Insufficient fuel delivery
3. TPS offset incorrect
4. TPS faulty
5. Faulty engine temperature sensor
6. Faulty injectors

Engine misses, hesitates, or stalls under load

1. Fuel injector(s), fuel filter, fuel line, or fuel pick-up dirty/restricted
2. Dirty air cleaner
3. Insufficient fuel pressure or fuel delivery
4. Vacuum (intake air) leak
5. Improper governor setting, adjustment or operation
6. Speed sensor malfunction
7. TPS faulty, mounting problem or "TPS Initialization Procedure" incorrect
8. Bad coil(s), spark plug(s), or wires

Low Power

1. Faulty/malfunctioning ignition system
2. Dirty air filter
3. Insufficient fuel delivery
4. Improper governor adjustment
5. Plugged/restricted exhaust
6. One injector not working
7. Basic engine problem exists
8. TPS faulty or mounting exists
9. Throttle plates in throttle body/intake manifold not fully opening to WOT stop (if so equipped)

Electrical System

The EFI system is a 12 VDC negative ground system, designed to operate down to a minimum of 7.0 volts. If system voltage drops below this level, the operation of voltage sensitive components such as the ECU, fuel pump, and injectors will be intermittent or disrupted, causing erratic operation or hard starting. A fully charged, 12 volt battery with a minimum of 350 cold cranking amps is important in maintaining steady and reliable system operation. Battery condition and state of charge should always be checked first when troubleshooting an operational problem.

Keep in mind that EFI-related problems are more often caused by the wiring harness or connections than by the EFI components. Even small amounts of corrosion or oxidation on the terminals can interfere with the milliamp currents used in system operation. Cleaning the connectors and grounds will solve problems in many cases. In an emergency situation, simply disconnecting and reconnecting the connectors may clean up the contacts enough to restore operation, at least temporarily.

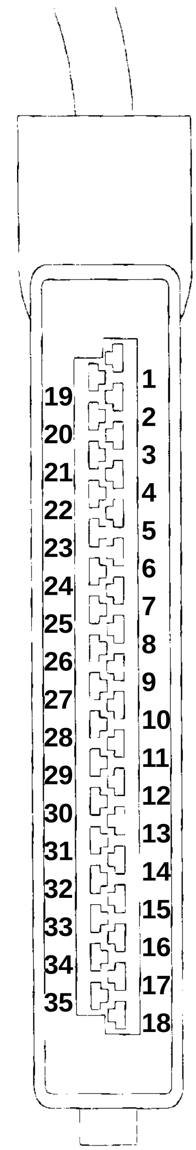
If a fault code indicates a problem with an electrical component, disconnect the ECU connector and test for continuity between the component connector terminals and the corresponding terminals in the ECU connector using an ohmmeter. Little or no resistance should be measured, indicating that the wiring of that particular circuit is OK. An illustrated listing of numerical terminal locations, for each style of ECU/ connector is provided on pages 5B.28, 5B.31, or 5B.32.

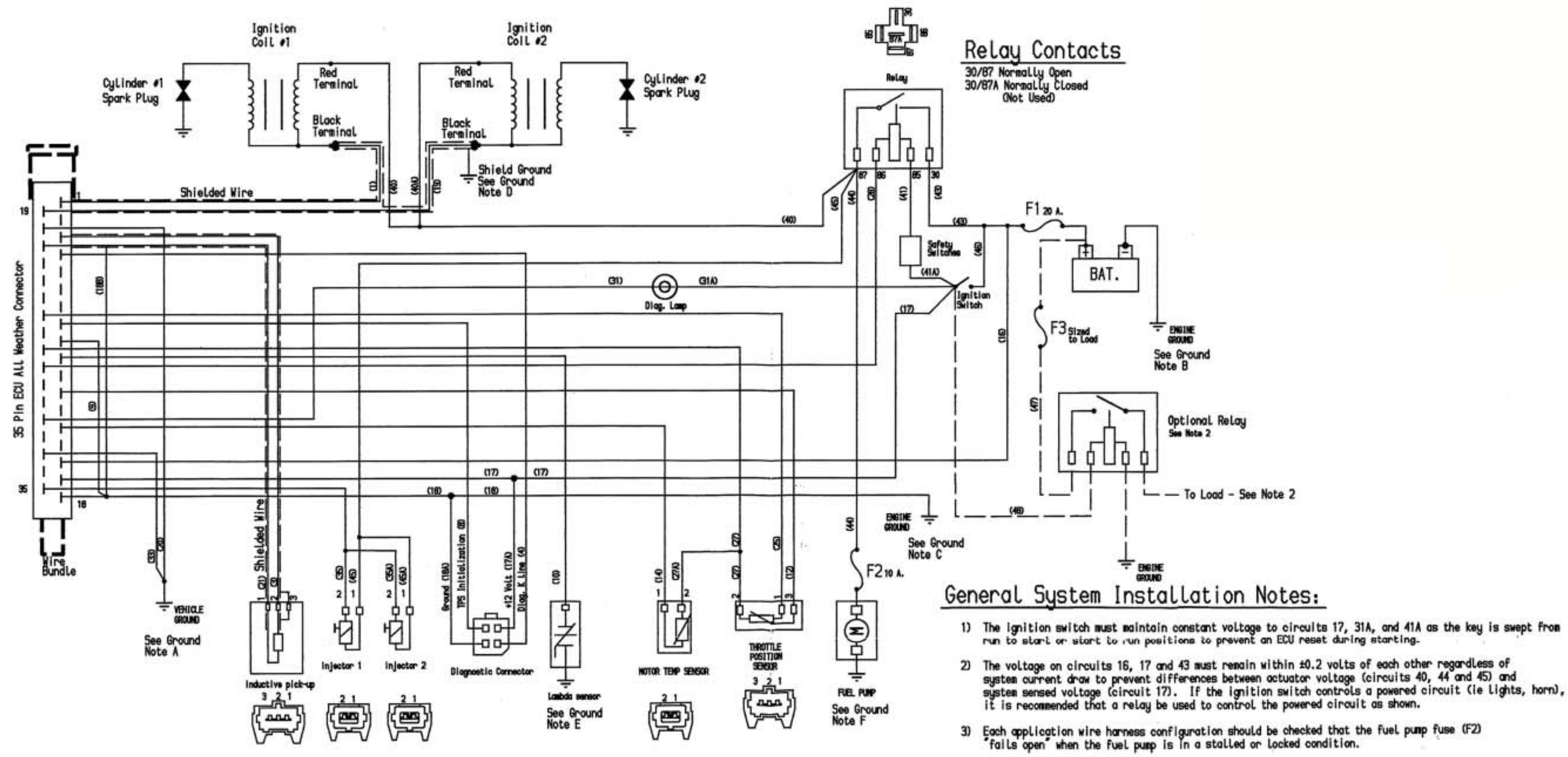
5B.28 for “35 Pin” (MA 1.7) Metal-Cased ECU
5B.31 for “24 Pin” (MSE 1.0) Plastic-Cased ECU
5B.32 for “32 Pin” (MSE 1.1) Plastic-Cased ECU

NOTE: When performing voltage or continuity tests, avoid putting excessive pressure on or against the connector pins. Flat pin probes are recommended for testing to avoid spreading or bending the terminals.

"35 Pin" (MA 1.7) Metal-Cased ECU Systems

Pin #	Component
1	Ignition Coil #1
2	Not used
3	Engine Speed Sensor
4	ECU Production Test Terminal
5	Not Used
6	Not Used
7	Not Used
8	TPS Initialization Terminal
9	Engine Ground
10	O_2 Sensor
11	Not Used
12	Throttle Position Sensor
13	Not Used
14	Oil Temperature Sensor
15	Not Used
16	ECU Permanent Battery Voltage
17	ECU Switched Battery Voltage
18	Engine Ground
19	Ignition Coil #2
20	Vehicle Ground
21	Engine Speed Sensor
22	Not Used
23	Not Used
24	Not Used
25	Throttle Position Sensor
26	Not Used
27	Throttle Position Sensor/Oil Temperature Sensor
28	Power Relay
29	Not Used
30	Not Used
31	Malfunction Indicator Light
32	Not Used
33	Vehicle Ground
34	Not Used
35	Fuel Injectors





General System Installation Notes:

1) The ignition switch must maintain constant voltage to circuits 17, 31A, and 41A as the key is swept from run to start or start to run positions to prevent an ECU reset during starting.

2) The voltage on circuits 16, 17 and 43 must remain within ±0.2 volts of each other regardless of system current draw to prevent differences between actuator voltage (circuits 40, 44 and 45) and system sensed voltage (circuit 17). If the ignition switch controls a powered circuit (ie lights, horn), it is recommended that a relay be used to control the powered circuit as shown.

3) Each application wire harness configuration should be checked that the fuel pump fuse (F2) "fails open" when the fuel pump is in a stalled or locked condition.

4) A resistive spark plug with either a resistive spark plug wire or resistive spark plug boot must be used to prevent electrical system noise.

5) The safety switches are to be wired in series with the power relay.

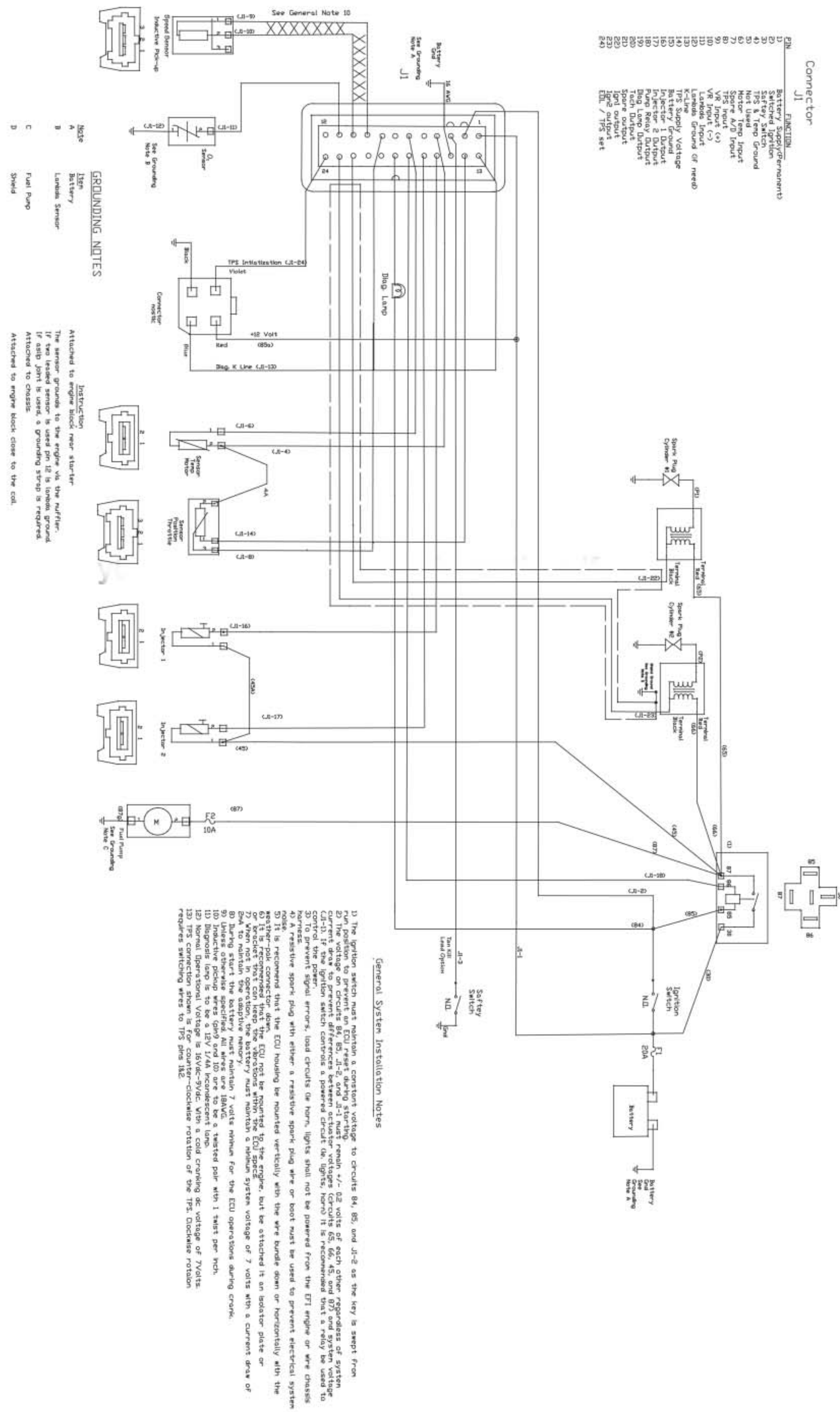
6) It is recommended that the ECU be mounted vertically with the wire bundle down or horizontally with the ALL Weather connector down.

7) It is recommended that the ECU housing be grounded to the chassis. The ECU should not be mounted to the engine nor should it be powerwashed.

8) When not in operation, the battery must maintain a minimum system voltage of 7 volts with a current draw of 20mA to maintain adaptive memory.

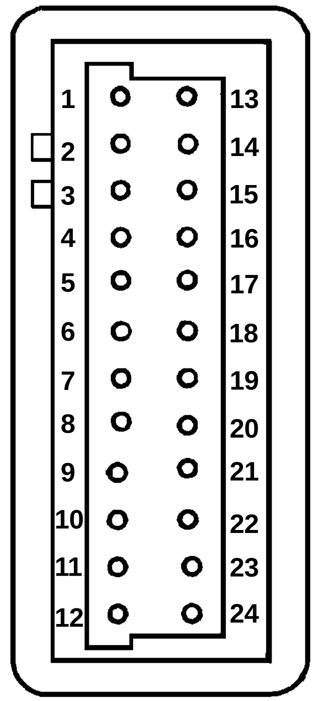
9) During a start, the battery must maintain 7 volts minimum system voltage for ECU operation during crank.

9) Unless otherwise specified: ALL wires are 18 AWG.



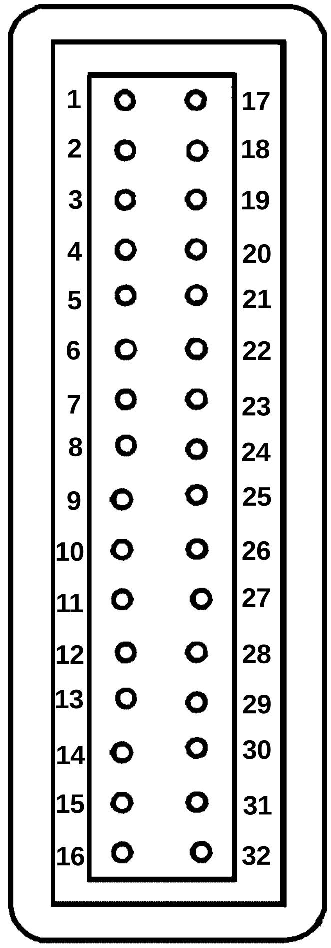
"24 Pin" (MSE 1.0) Plastic-Cased ECU Systems

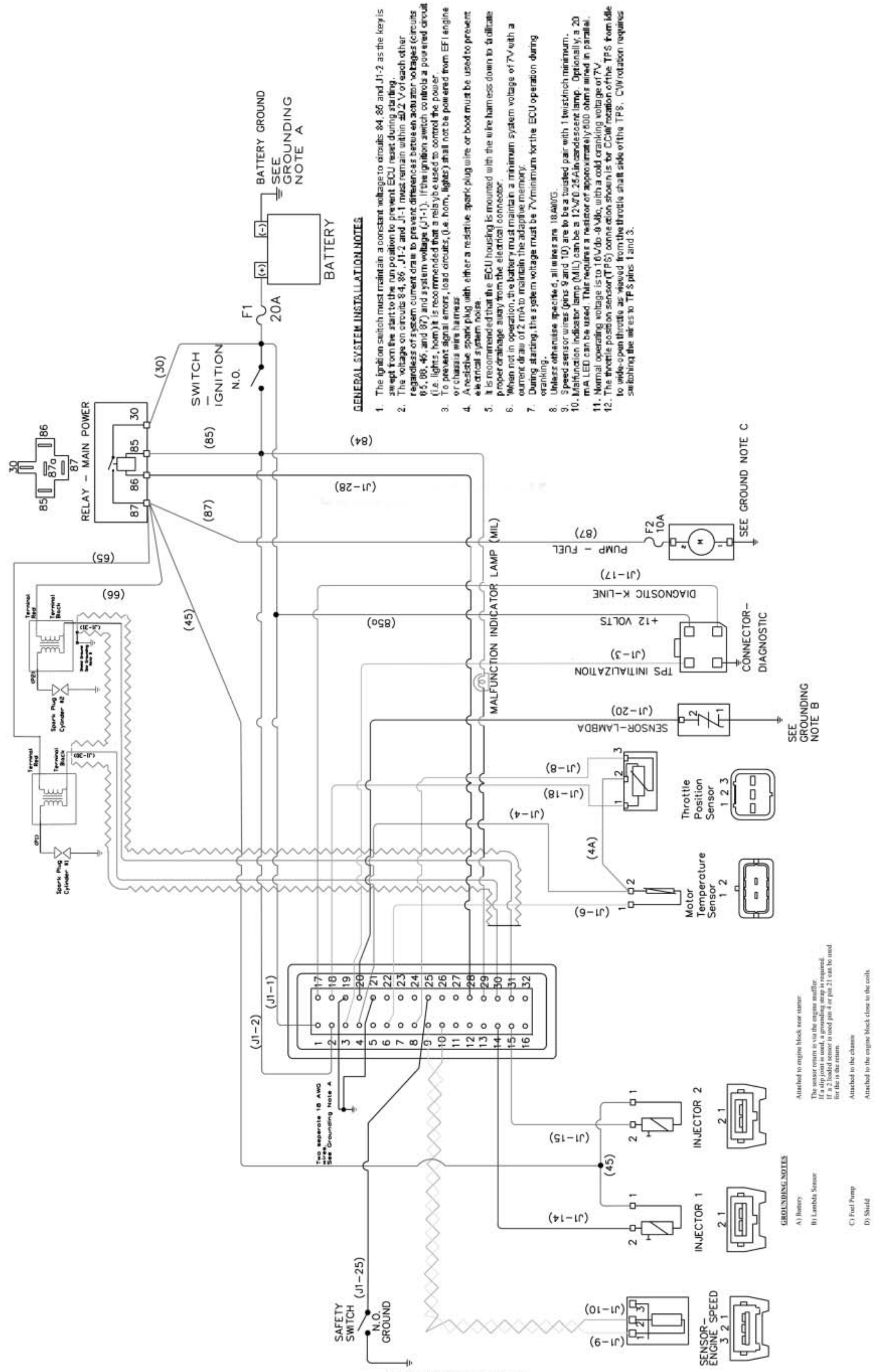
Pin #	Function
1	Permanent Battery Voltage
2	Switched Ignition Voltage
3	Safety Switch
4	Throttle Position Sensor (TPS) and Temperature Sensor Ground
5	Not Used
6	Oil Temperature Sensor Input
7	Not Used
8	Throttle Position Sensor (TPS) Input
9	Speed Sensor Input
10	Speed Sensor Ground
11	Oxygen Sensor Input
12	Not Used (Oxygen Sensor Ground if needed)
13	Diagnostic Line
14	Throttle Position Supply Voltage
15	Battery Ground
16	Injector 1 Output
17	Injector 2 Output
18	Main Relay Output
19	Malfunction Indicator Light (MIL)
20	Not Used (Tach Output if needed)
21	Not Used
22	Ignition Coil #1 Output
23	Ignition Coil #2 Output
24	TPS Initialization Terminal



"32 Pin" (MSE 1.1) Plastic-Cased ECU Systems

Pin #	Function
1	Permanent Battery Voltage
2	Switched Battery Voltage
3	TPS Set; "Auto-Learn" Initialization Terminal
4	Throttle Position Sensor (TPS) and Temperature Sensor Ground
5	Not Used
6	Oil Temperature Sensor Input
7	Not Used
8	Throttle Position Sensor (TPS) Input
9	Speed Sensor Input (+)
10	Speed Sensor Ground (-)
11	Not Used
12	Not Used
13	Not Used
14	Injector 1 Output
15	Injector 2 Output
16	Not Used
17	Diagnostic Line
18	Throttle Position/Temperature Sensor Supply Voltage
19	Battery Ground
20	Oxygen Sensor Input
21	Not Used
22	Not Used
23	Not Used
24	Not Used
25	Safety Switch Input
26	Not Used
27	Not Used
28	Main Relay Output
29	Malfunction Indicator Light (MIL)
30	Ignition Coil #1 Output
31	Ignition Coil #2 Output
32	Not Used





GENERAL SYSTEM INSTALLATION NOTES

1. The ignition switch must maintain a constant voltage to circuits 84, 86 and J1-2 as the key is swept from the start to the run position to prevent ECU reset during starting.
2. The voltage on circuits 84, 86 , J1-2 and J1-1 must remain within ±0.2 V of each other regardless of system current draw to prevent differences between actuator voltages (circuits 85, 86, 45, and 87) and system voltage (J1-1). If the ignition switch controls a powered circuit (i.e. lights, horn) it is recommended that a relay be used to control the power.
3. To prevent signal errors, load circuits, (i.e. horn, lights) shall not be powered from EFI engine or chassis wire harness
4. A resistive spark plug with either a resistive spark plug wire or boot must be used to prevent electrical system noise.
5. It is recommended that the ECU housing is mounted with the wire harness down to facilitate proper drainage away from the electrical connector.
6. When not in operation, the battery must maintain a minimum system voltage of 7V with a current draw of 2 mA to maintain the adaptive memory.
7. During starting, the system voltage must be 7V minimum for the ECU operation during cranking.
8. Unless otherwise specified, all wires are 18AWG.
9. Speed sensor wires (pins 9 and 10) are to be a twisted pair with 1 twist/inch minimum.
10. Malfunction indicator lamp (MIL) can be a 12V/0.25A incandescent lamp. Optionally, a 20 mA LED can be used. This requires a resistor of approximately 600 ohms wired in parallel.
11. Normal operating voltage is to 16Vdc -9 Vdc, with a cold cranking voltage of 7V.
12. The throttle position sensor (TPS) connection shown is for CCW rotation of the TPS from idle to wide-open throttle as viewed from the throttle shaft side of the TPS. CW rotation requires switching the wires to TPS pins 1 and 3.

GROUNDING NOTES

A) Battery — Attached to engine block near starter.

B) Lambda Sensor — The sensor return is via the engine muffler. If a slip joint is used, a grounding strap is required. If a 2 loaded sensor is used pin 4 or pin 21 can be used for the is the return.

C) Fuel Pump — Attached to the chassis

D) Shield — Attached to the engine block close to the coils.

Fuel System

WARNING: Fuel System Under Pressure!
The fuel system operates under high pressure. System pressure must be relieved through the test valve in the fuel rail prior to servicing or removing any fuel system components. Do not smoke or work near heaters or other fire hazards. Have a fire extinguisher handy and work only in a well-ventilated area.

The function of the fuel system is to provide sufficient delivery of fuel at the system operating pressure of 39 psi ± 3. If an engine starts hard, or turns over but will not start, it may indicate a problem with the EFI fuel system. A quick test will verify if the system is operating.

1. Disconnect and ground the spark plug leads.

2. Complete all safety interlock requirements and crank the engine for approximately 3 seconds.

3. Remove the spark plugs and check for fuel at the tips.

    a. If there is fuel at the tips of the spark plugs, the fuel pump and injectors are operating.

    b. If there is no fuel at the tips of the spark plugs, check the following:

        1. Make sure the fuel tank contains clean, fresh, proper fuel.

        2. Make sure that vent in fuel tank is open.

        3. Make sure fuel tank valve (if so equipped) is fully opened.

        4. Make sure battery is supplying proper voltage.

        5. Check that the fuses are good, and that all electrical and fuel line connections are good.

        6. Test fuel pump and relay operation as described earlier under ‘‘Fuel Pump – Service.’’

Fault Codes

The ECU continuously monitors engine operation against preset performance limits. If the operation is outside the limits, the ECU activates the MIL and stores a diagnostic code in its fault memory. If the component or system returns to proper function, the ECU will eventually self-clear the fault code and turn off the MIL. If the MIL stays illuminated, it warns the customer that dealer service is required. Upon receipt, the dealer technician can access the fault code(s) to help determine what portion of the system is malfunctioning. The 2-digit blink codes available based upon the style of ECU are listed on pages 5B.35-5B.36.

The codes are accessed through the key switch and displayed as blinks or flashes of the MIL. Access the codes as follows.

1. Start with the key switch off.

2. Turn the key switch on-off-on-off-on, leaving it on in the third sequence. The time between sequences must be less than 2.5 seconds.

3. Any stored fault codes will then be displayed as a series of MIL blinks (from 2 to 6) representing the first digit, followed by a pause, and another series of blinks (from 1 to 6) for the second digit (see Figure 5B-43).

    a. It’s a good idea to write down the codes as they appear, as they may not be in numerical sequence.

    b. Code 61 will always be the last code displayed, indicating the end of code transmission. If code 61 appears immediately, no other fault codes are present.

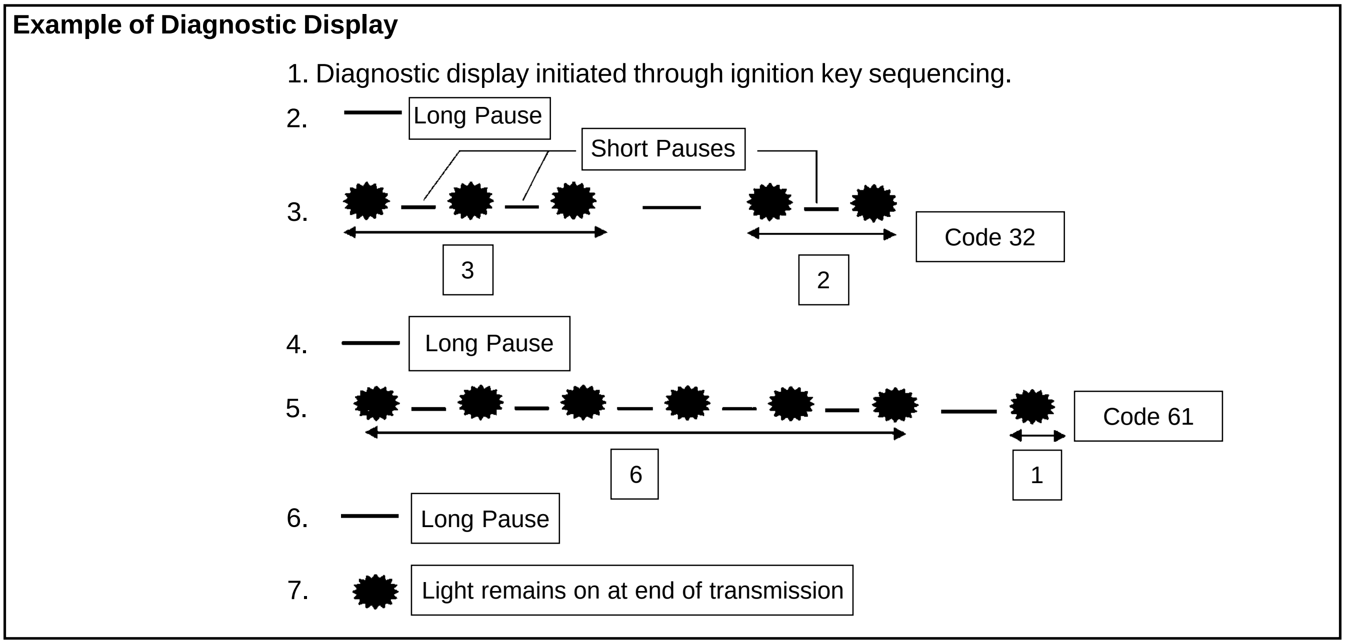


Figure 5B-43.

After the problem has been corrected, the fault codes may be cleared as follows.

1. Disconnect the negative (-) battery cable from battery terminal, or remove the main fuse for the ECU for approximately 1 minute.

2. Reconnect the cable and tighten securely, or reinstall the main fuse. Start the engine and allow it to run for several minutes. The MIL should remain off if the problem was corrected, and the fault codes should not reappear (codes 31, 32, 33, and 34 may require 10-15 minutes of running to reappear).

The following chart lists the fault codes, what they correspond to, and what the visual indications will be. Following the chart is a list of the individual codes with an explanation of what triggers them, what symptoms might be expected, and the probable causes.

Diagnostic Code Summary

Blink Code	OBD2 P-Code Applicable to: "32 Pin" (MSE 1.1) ECU/System Only	Connection or Failure Description	"35 Pin" (MA 1.7) Metal-Cased ECU/System	"24 Pin" (MSE 1.0) Plastic-Cased ECU/System	"32 Pin" (MSE 1.1) Plastic-Cased ECU/System	Note
-	-	No RPM Signal	Y	Y	Y	
21	P0335	Loss of Synchronization	Y	Y	Y	
22	P0120	TPS - Signal Implausible	N	N	N	2
22	P0122	TPS - Open or Short Circuit to Ground	Y	Y	Y	
22	P0123	TPS - Short Circuit to Battery	Y	Y	Y	
23	P0601	Defective ECU	Y	Y	Y	
24		Engine Speed Sensor	Y	Y	Y	9
31	P0174	System too Lean	Y	Y	Y	6

cont. on next page

Blink Code	OBD2 P-Code Applicable to: "32 Pin" (MSE 1.1) ECU/System Only	Connection or Failure Description	"35 Pin" (MA 1.7) Metal-Cased ECU/System	"24 Pin" (MSE 1.0) Plastic-Cased ECU/System	"32 Pin" (MSE 1.1) Plastic-Cased ECU/System	Note
31	P0132	O_2 Sensor Circuit: Shorted to Battery	Y	N	Y	3
32	P0134	O_2 Sensor Circuit: No Activity Detected	N	N	N	8
33	P0175	System too Rich	Y	Y	Y	7,8
33	P0020	O_2 Sensor Control at Upper Limit	Y	Y	Y	8
34	P0171	Maximum Adaption Limit Reached	Y	Y	Y	8
34	P0172	Minimum Adaption Limit Reached	Y	Y	Y	8
42	P0117	Temperature Sensor Circuit: Shorted to Ground	Y	Y	Y	
42	P0118	Temperature Sensor Circuit: Open Circuit or Short to Battery	Y	Y	Y	
43	N/A	Failure Completing Autolearn - TPS Offset below minimum allowable limit	N/A	N/A	Y	
44	N/A	Failure Completing Autolearn - TPS offset above maximum allowable limit	N/A	N/A	Y	
51	P1260	Injector 1 - Open Circuit	N/A	N/A	Y	
51	P0261	Injector 1 - Short Circuit to Ground	N/A	N/A	Y	
51	P0262	Injector 1 - Short Circuit to Battery	N/A	N/A	Y	
52	P1263	Injector 2 - Open Circuit	N/A	N/A	Y	
52	P0264	Injector 2 - Short Circuit to Ground	N/A	N/A	Y	
52	P0265	Injector 2 - Short Circuit to Battery	N/A	N/A	Y	
55	P1651	Diagnostic Lamp - Open Circuit	N/A	N/A	Y	
55	P1652	Diagnostic Lamp - Short Circuit to Ground	N/A	N/A	Y	
55	P1653	Diagnostic Lamp - Short Circuit to Battery	N/A	N/A	Y	
56	P1231	Pump Relay - Open Circuit	N/A	N/A	Y	
56	P1232	Pump Relay - Short Circuit to Ground	N/A	N/A	Y	
56	P1233	Pump Relay - Short Circuit to Battery	N/A	N/A	Y	
61		End of Code Transmission	Y	Y	Y	

Note:
1. Idle Switch not used.
2. Diagnostic of "TPS - Signal Implausible" is disabled in code.
3. "O_2 Sensor Short to Battery" diagnostic detection is disabled with SAS fuel-cutoff calibrated out.
4. Air Temperature Sensor not used.
5. "Temperature Sensor Signal Implausible": diagnostic detection is calibrated out, with TPLAUS set to -50°C.
6. System too Lean used to be "O_2 Sensor - Short to Ground (P0131)."
7. "System too Rich" used to be "O_2 Sensor Control at Lower Limit (P0019)."
8. Obtainable only with ECU 24 584 28-S or later.
9. Will not blink out.

Code: **21**
Source: Engine Speed Sensor
Explanation: ECU receiving inconsistent tooth count signals from speed sensor.
Expected Engine Response: Possible misfire as ECU attempts to resynchronize, during which time fuel and spark calculations are not made.

Possible Causes:

1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or incorrect air gap.
   c. Flywheel key sheared.

2. Speed Sensor Ring Gear Related
   a. Damaged teeth.
   b. Varying gap (gear loose/out of alignment).

3. Engine Wiring Harness Related
   "35 Pin" (MA 1.7) Metal-Cased ECU:
   a. Pin circuits 3 and/or 21 wiring or connectors.
   b. Shielding for pin circuits 3 and/or 21 damaged or not properly grounded.
   c. Poor or improper grounds in system (battery, ECU, oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 3 and/or 21 routed near noisy electrical signals (coils, spark plug lead, plug connector).

3. Engine Wiring Harness Related
   "24 Pin" (MSE 1.0) Plastic-Cased ECU:
   a. Pin circuits 9 and/or 10 wiring or connectors.
   b. Shielding for pin circuits 9 and/or 10 damaged or not properly grounded.
   c. Poor or improper grounds in system (battery, ECU oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 9 and/or 10 routed near noisy electrical signals (coils, spark plug lead, plug connector).

3. Engine Wiring Harness Related
   "32 Pin" (MSE 1.1) Plastic-Cased ECU:
   a. Pin circuits 9 and/or 10 wiring or connectors.
   b. Shielding for pin circuits 9 and/or 10 damaged or not properly grounded.
   c. Poor or improper grounds in system (battery, ECU, oxygen sensor, shielding, fuel pump, ignition output).
   d. Pin circuits 9 and/or 10 routed near noisy electrical signals (coils, spark plug lead, plug connector).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

5. Ignition System Related
   a. Non-resistor spark plug(s) used.

Code: **22**
Source: Throttle Position Sensor (TPS)
Explanation: Unrecognizable signal is being sent from sensor (too high, too low, inconsistent).
Expected Engine Response: A "limp-home" operating mode occurs, with an overall decrease in operating performance and efficiency. Fuel delivery is based upon the oxygen sensor and five mapped values only. Rich running (black smoke) will occur until "closed loop" operation is initiated. A stumble or misfire on hard acceleration and/or erratic operation may be exhibited.

Possible Causes:

1. TPS Sensor Related
   a. Sensor connector or wiring.
   b. Sensor output affected or disrupted by dirt, grease, oil, wear, or breather tube position (must be to side opposite the TPS).
   c. Sensor loose on throttle body manifold.

2. Throttle Body Related
   a. Throttle shaft or bearings worn/damaged.

3. Engine Wiring Harness Related
   "35 Pin" (MA 1.7) Metal-Cased ECU:
   a. Pin circuits 12, 25 and/or 27 damaged (wiring or connectors).
   b. Pin circuits 12, 25 and/or 27 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 25).

3. Engine Wiring Harness Related
   "24 Pin" (MSE 1.0) Plastic-Cased ECU:
   a. Pin circuits 4, 8, and/or 14 damaged (wiring, connectors).
   b. Pin circuits 4, 8, and/or 14 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 14).

3. Engine Wiring Harness Related
   "32 Pin" (MSE 1.1) Plastic-Cased ECU:
   a. Pin circuits 4, 8, and/or 18 damaged (wiring, connectors).
   b. Pin circuits 4, 8, and/or 18 routed near noisy electrical signal (coils, alternator).
   c. Intermittent 5 volt source from ECU (pin circuit 18).

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **23**
Source: ECU
Explanation: ECU is unable to recognize or process signals from its memory.
Expected Engine Response: Engine will not run.

Possible Causes:
1. ECU (internal memory problem).
   a. Diagnosable only through the elimination of all other system/component faults.

Code: **24** (Will not blink out)
Source: Engine Speed Sensor
Explanation: No tooth signal from speed sensor. MIL light will not go out when cranking.
Expected Engine Response: None-engine will not start or run as ECU is unable to estimate speed.

Possible Causes:
1. Engine Speed Sensor Related
   a. Sensor connector or wiring.
   b. Sensor loose or air gap incorrect.

2. Speed Sensor Wheel Related
   a. Damaged teeth.
   b. Gap section not registering.

3. Engine Wiring Harness Related
   a. Pin circuit wiring or connectors.
      Pin(s) 3 and/or 21 for **"35 Pin" (MA 1.7) Metal-Cased ECU**.
      Pin(s) 9 and/or 10 for **"24 Pin" (MSE 1.0) Plastic-Cased ECU**.
      Pin(s) 9 and/or 10 for **"32 Pin" (MSE 1.1) Plastic-Cased ECU**.

4. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **31**
Source: Fuel Mixture or Oxygen Sensor
Explanation: "System too lean." Oxygen sensor not sending expected voltage to ECU.
Expected Engine Response: System operates under "open loop" control only. Until fault is detected and registered by ECU, engine will run rich if oxygen sensor is shorted to ground or lean if it is shorted to battery voltage. After fault is detected, performance can vary, depending on cause. If performance is pretty good, the problem is probably with the oxygen sensor, wiring, or connectors. If the engine is still running rich (laboring, short on power) or lean (popping or misfiring), the fuel mixture is suspect, probably incorrect TPS initialization or low fuel pressure.

Possible Causes:
1. TPS Initialization Incorrect
   a. Lean condition (check oxygen sensor signal with VOA and see Oxygen Sensor section).

2. Engine Wiring Harness Related
   a. Pin circuit wiring or connectors.
      Pin 10 for **"35 Pin" (MA 1.7) Metal-Cased ECU**.
      Pin 11 for **"24 Pin" (MSE 1.0) Plastic-Cased ECU.**
      Pin 20 for **"32 Pin" (MSE 1.1) Plastic-Cased ECU**.

3. Low Fuel Pressure

4. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Exhaust leak.
   c. Poor ground path to engine (sensor is case grounded).

5. Poor system ground from ECU to engine, causing rich running while indicating lean.

Code: **32**
Source: Oxygen Sensor
Explanation: No change in the sensor output signal.
Expected Engine Response: "Open loop" operation only, may cause a drop in system performance and fuel efficiency.

Possible Causes:

1. Engine Wiring Harness Related
   a. Pin circuit wiring or connectors.
      Pin 10 for **"35 Pin" (MA 1.7) Metal-Cased ECU**.
      Pin 11 for **"24 Pin" (MSE 1.0) Plastic-Cased ECU**.
      Pin 20 for **"32 Pin" (MSE 1.1) Plastic-Cased ECU**.

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Sensor below the minimum operating temperature (375°C, 709°F).
   d. Poor ground path from sensor to engine (sensor grounds through shell, see Oxygen Sensor section).

3. TPS Sensor Related
   a. Throttle plate position incorrectly set or registered during "Initialization."
   b. TPS problem or malfunction.

4. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 17 for metal-cased ECU, pin circuit 2 for plastic-cased ECU) and actual injector voltage (circuit 45/45A).

5. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pump, fuel pressure.
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bores).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak.
   f. Fuel in the crankcase oil.
   g. Blocked or restricted fuel return circuit to tank.

6. ECU/Harness Related
   a. ECU-to-harness connection problem.

Code: **33**
Source: Oxygen Sensor/Fuel System
Explanation: "System too rich." Temporary fuel adaptation control is at the upper limit.
Expected Engine Response: Erratic performance. Will run rich (smoke).

Possible Causes:

1. Fuel Supply Related (nothing lean – only rich)
   a. Restricted return line causing excessive fuel pressure.
   b. Fuel inlet screen plugged (in-tank fuel pump only).
   c. Incorrect fuel pressure at fuel rail.

2. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit wiring or connectors.
      Pin 10 for **"35 Pin" (MA 1.7) Metal-Cased ECU**.
      Pin 11 for **"24 Pin" (MSE 1.0) Plastic-Cased ECU**.
      Pin 20 for **"32 Pin" (MSE 1.1) Plastic-Cased ECU**.

Code: **34**
Source: Oxygen Sensor/Fuel System Components
Explanation: Long term fuel adaptation control is at the upper or lower limit.
Expected Engine Response: System operates "closed loop." No appreciable performance loss as long as the temporary adaptation can provide sufficient compensation.

Possible Causes:

1. Oxygen Sensor Related
   a. Sensor connector or wiring problem.
   b. Sensor contaminated or damaged.
   c. Exhaust leak.
   d. Poor ground path.
   e. Pin circuit wiring or connectors.
      Pin 10 for **"35 Pin" (MA 1.7) Metal-Cased ECU**.
      Pin 11 for **"24 Pin" (MSE 1.0) Plastic-Cased ECU**.
      Pin 20 for **"32 Pin" (MSE 1.1) Plastic-Cased ECU**.

2. TPS Sensor Related
   a. Throttle plate position incorrect during "Initialization" procedure.
   b. TPS problem or malfunction.

3. Engine Wiring Harness Related
   a. Difference in voltage between sensed voltage (pin circuit 17 for metal-cased ECU, pin circuit 2 for plastic-cased ECU) and actual injector voltage (circuit 45/45A).
   b. Problem in wiring harness.
   c. ECU-to-harness connection problem.

4. Systems Related
   a. Ignition (spark plug, plug wire, ignition coil.
   b. Fuel (fuel type/quality, injector, fuel pressure, fuel pump).
   c. Combustion air (air cleaner dirty/restricted, intake leak, throttle bores).
   d. Base engine problem (rings, valves).
   e. Exhaust system leak (muffler, flange, oxygen sensor mounting boss, etc.).
   f. Fuel in the crankcase oil.
   g. Altitude.
   h. Blocked or restricted fuel return circuit to tank.

Code: **42**
Source: Engine (Oil) Temperature Sensor
Explanation: Not sending proper signal to ECU.
Expected Engine Response: Engine may be hard to start because ECU can't determine correct fuel mixture.

Possible Causes:
1. Temperature Sensor Related.
   a. Sensor wiring or connection.

2. Engine Wiring Harness Related
   "35 Pin" (MA 1.7) Metal-Cased ECU:
   a. Pin circuits 14 and/or 27A damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

2. Engine Wiring Harness Related
   "24 Pin" (MSE 1.0) Plastic-Cased ECU:
   a. Pin circuits 4, 6 and/or 4A damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

2. Engine Wiring Harness Related
   "32 Pin" (MSE 1.1) Plastic-Cased ECU:
   a. Pin circuits 4, 6 and/or (4A) damaged (wires, connectors) or routed near noisy signal (coils, alternator, etc.).
   b. ECU-to-harness connection problem.

3. System Related
   a. Engine is operating above the 176°C (350°F) temperature sensor limit.

Code: **43 and 44** **"32 Pin" (MSE 1.1) Plastic-Cased ECU only.**
Source: TPS "Auto-Learn" initialization function failed, throttle angle out of learning range.
Explanation: While performing the TPS "Auto-Learn" function, the measured throttle angle was not within acceptable limits.
Expected Engine Response: MIL illuminated. Engine will continue to run but not properly. Upon restart TPS Auto-Learn function will run again unless voltage to ECU disconnected to clear memory.

Possible Causes:
1. TPS Related
   a. TPS rotated on throttle shaft assembly beyond allowable range.
   b. TPS bad.

2. Engine Wiring Harness Related
   a. Broken or shorted wire in harness.
      ECU pin 18 to TPS pin 1.
      ECU pin 4 to TPS pin 2.
      ECU pin 8 to TPS pin 3.

3. Throttle Body Related
   a. Throttle shaft inside TPS worn, broken, or damaged.
   b. Throttle plate loose or misaligned.
   c. Throttle plate bent or damaged allowing extra airflow past, or restricting movement.

4. ECU Related
   a. Circuit providing voltage or ground to TPS damaged.
   b. TPS signal input circuit damaged.

5. Oxygen Sensor/Harness Related.
   a. Oxygen sensor bad.
   b. Wiring problem to oxygen sensor.
   c. Muffler leak (causing O_2 sensor to falsely indicate a lean condition).
   d. Bad ground between ECU and Engine.

Code: 51 **"32 Pin" (MSE 1.1) Plastic-Cased ECU only.**
Source: Injector #1 circuit open, shorted to ground, or shorted to battery.
Explanation: Injector #1 is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run very poorly with only one cylinder functioning.

Possible Causes:

1. Injector Related
   a. Injector coil shorted or opened.

2. Engine Wiring Harness Related
   a. Broken or shorted wire in harness.
   ECU pin 14 to injector pin 2. ECU pin 28 to fuel pump relay pin 86. Note: after key-off then key-on code 56 would be set also. Fuel pump relay pin 87 to injector pin 1.
   b. Open main fuse F1.

3. Fuel Pump Relay Related
   a. Bad fuel pump relay.
   Primary side functional but pin 30 to pin 87 remains open. Primary side pin 85 to pin 86 is either open, or shorted during engine operation. Note: after key-off then key-on code 56 would be set also.

4. ECU Related
   a. Circuit controlling injector #1 damaged.
   b. Circuit controlling fuel pump relay damaged.

Code: 52 **"32 Pin" (MSE 1.1) Plastic-Cased ECU only.**
Source: Injector #2 circuit open, shorted to ground, or shorted to battery.
Explanation: Injector #2 is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run very poorly with only one cylinder functioning.

Possible Causes:

1. Injector Related
   a. Injector coil shorted or opened.

2. Engine Wiring Harness Related
   a. Broken or shorted wire in harness. ECU pin 15 to injector pin 2. ECU pin 28 to fuel pump relay pin 86. Note: after key-off then key-on code 56 would be set also. Fuel pump relay pin 87 to injector pin 1.
   b. Opened main fuse F1.

3. Fuel Pump Relay Related
   a. Bad fuel pump relay.
   Primary side functional, but pin 30 to pin 87 remains open.
   Primary side pin 85 to pin 86 is open or shorted during engine operation. Note: after key-off then key-on code 56 would be set also.

4. ECU Related
   a. Circuit controlling injector #2 damaged.
   b. Circuit controlling fuel pump relay damaged.

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Code: 55 **"32 Pin" (MSE 1.1) Plastic-Cased ECU only.**
Source: MIL (Diagnostic lamp) circuit open, shorted to ground, or shorted to battery.
Explanation: MIL is not functioning because the circuit is open, shorted to ground, or shorted to battery.
Expected Engine Response: Engine will run normally if no other errors are present.

Possible Causes:

1. MIL (diagnostic lamp) Related
   a. MIL element opened or element shorted to ground.
   b. Lamp missing.

2. Engine Wiring Harness Related
   a. Broken or shorted wire in harness.
   ECU pin 29 to lamp open or shorted.

3. Vehicle Wiring Harness Related
   a. Broken or shorted wire in harness.
   Power lead to MIL open or shorted.

4. ECU Related
   a. Circuit controlling lamp damaged.

Code: **56** **"32 Pin" (MSE 1.1) Plastic-Cased ECU only.**

Source: Fuel pump relay circuit open, shorted to ground, or shorted to battery

Explanation: Fuel pump, ignition coils, and fuel injectors will not function because the fuel pump relay circuit is either open, shorted to ground, or may be “on” continuously if shorted to battery.

Expected Engine Response: Engine will not run, or fuel pump will continue to run when switch is off.

Possible Causes:

1. Fuel Pump Relay Related
   a. Bad fuel pump relay.
      Primary side open or shorted.

2. Fuel Pump Related
   a. Fuel pump open or shorted internally.

3. Engine Wiring Harness Related
   a. Fuel pump fuse F1 open.
   b. Broken or shorted wire in harness.
      ECU pin 28 to fuel pump relay pin 86.
      Ignition switch to fuel pump relay pin 85.

4. ECU Related
   a. Circuit controlling fuel pump relay damaged.

Code: **61**

Source:

Explanation: Denotes the end of fault codes. If signaled first, no other fault codes are present.

Troubleshooting Flow Chart

The following flow chart (on page 5B.43) provides an alternative method of troubleshooting the EFI system. The chart will enable you to review the entire system in about 10-15 minutes. Using the chart, the accompanying diagnostic aids (listed after the chart), and any signaled fault codes, you should be able to quickly locate any problems within the system.

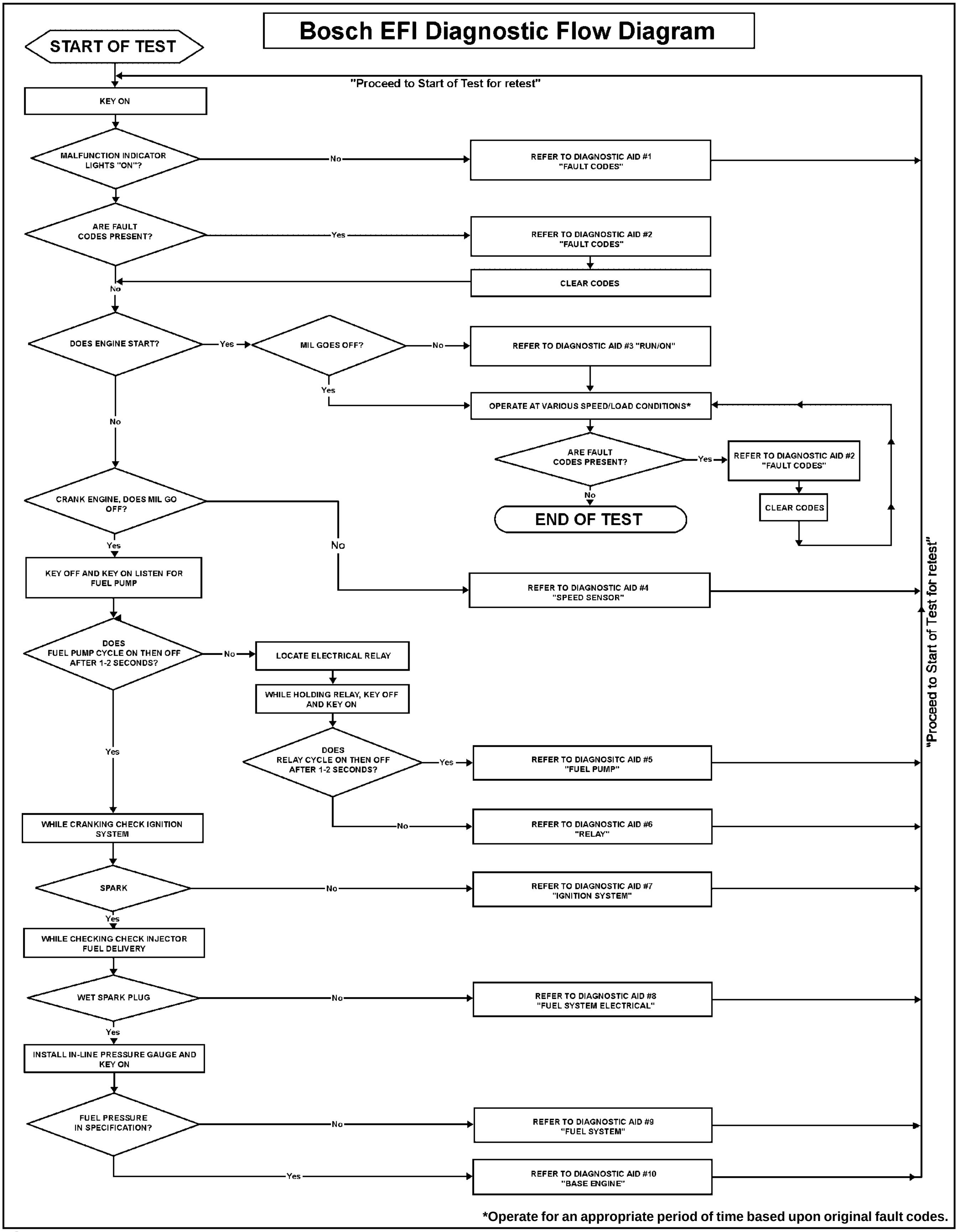

Bosch EFI Diagnostic Flow Diagram
START OF TEST
"Proceed to Start of Test for retest"
KEY ON
MALFUNCTION INDICATOR LIGHTS "ON"?
No
REFER TO DIAGNOSTIC AID #1 "FAULT CODES"
ARE FAULT CODES PRESENT?
Yes
REFER TO DIAGNOSTIC AID #2 "FAULT CODES"
CLEAR CODES
No
DOES ENGINE START?
Yes
MIL GOES OFF?
No
REFER TO DIAGNOSTIC AID #3 "RUN/ON"
Yes
OPERATE AT VARIOUS SPEED/LOAD CONDITIONS*
No
ARE FAULT CODES PRESENT?
Yes
REFER TO DIAGNOSTIC AID #2 "FAULT CODES"
CLEAR CODES
No
END OF TEST
CRANK ENGINE, DOES MIL GO OFF?
No
REFER TO DIAGNOSTIC AID #4 "SPEED SENSOR"
Yes
KEY OFF AND KEY ON LISTEN FOR FUEL PUMP
DOES FUEL PUMP CYCLE ON THEN OFF AFTER 1-2 SECONDS?
No
LOCATE ELECTRICAL RELAY
WHILE HOLDING RELAY, KEY OFF AND KEY ON
DOES RELAY CYCLE ON THEN OFF AFTER 1-2 SECONDS?
Yes
REFER TO DIAGNOSITC AID #5 "FUEL PUMP"
No
REFER TO DIAGNOSTIC AID #6 "RELAY"
Yes
WHILE CRANKING CHECK IGNITION SYSTEM
SPARK
No
REFER TO DIAGNOSTIC AID #7 "IGNITION SYSTEM"
Yes
WHILE CHECKING CHECK INJECTOR FUEL DELIVERY
WET SPARK PLUG
No
REFER TO DIAGNOSTIC AID #8 "FUEL SYSTEM ELECTRICAL"
Yes
INSTALL IN-LINE PRESSURE GAUGE AND KEY ON
FUEL PRESSURE IN SPECIFICATION?
No
REFER TO DIAGNOSTIC AID #9 "FUEL SYSTEM"
Yes
REFER TO DIAGNOSTIC AID #10 "BASE ENGINE"
"Proceed to Start of Test for retest"
*Operate for an appropriate period of time based upon original fault codes.

Figure 5B-44.

Flow Chart Diagnostic Aids

Diagnostic Aid #1 "SYSTEM POWER" (MIL does not illuminate when key is turned "**on**")

Possible causes:

1. Battery
2. Main system fuse
3. MIL light bulb burned out
4. MIL electrical circuit problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuits 31 and 31A.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuits 19 and 84.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuits 29 and 84.
5. Ignition switch
6. Permanent ECU power circuit problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuit 16.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuit 1.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuit 1.
7. Switched ECU power circuit problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuit 17.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuit 2.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuit 2.
8. ECU grounds
9. ECU

Diagnostic Aid #2 "FAULT CODES" (Refer to detailed fault code listing before flow chart and "servicing" information for the respective components)

1. Code 21 - Engine Speed Synchronization
2. Code 22 - Throttle Position Sensor (TPS)
3. Code 23 - Engine Control Unit (ECU)
4. Code 31 - Oxygen Sensor
5. Code 32 - Oxygen Sensor
6. Code 33 - Fuel System (temporary adaptation factor)
7. Code 34 - Fuel System (permanent adaptation factor)
8. Code 42 - Engine (Oil) Temperature Sensor
9. Code 43 - TPS "Auto-Learn" Initialization Function (Below Min. Limit), **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
10. Code 44 - TPS "Auto-Learn" Initialization Function (Above Max. Limit), **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
11. Code 51 - Injector 1, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
12. Code 52 - Injector 2, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
13. Code 55 - MIL Light, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
14. Code 56 - Pump Relay, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
15. Code 61 - End of Fault/Blink Code Transmission.

Diagnostic Aid #3 "RUN/ON" (MIL remains "on" while engine is running)*

Possible causes:

1. Fault codes which turn on MIL when engine is running.
   a. Code 21 - Engine Speed Synchronization
   b. Code 22 - Throttle Position Sensor (TPS)
   c. Code 23 - Engine Control Unit (ECU)
   d. Code 31 - Oxygen Sensor (shorted)
   e. Code 34 - Fuel System (permanent adaptation at limit)
   f. Code 42 - Engine (Oil) Temperature Sensor
   g. Code 43 - TPS "Auto-Learn" Initialization Function (Below Min. Limit), **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
   h. Code 44 - TPS "Auto-Learn" Initialization Function (Above Max. Limit) **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
   i. Code 51 - Injector 1, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
   j. Code 52 - Injector 2, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
   k. Code 55 - MIL Light, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
   l. Code 56 - Pump Relay, **"32 Pin" (MSE 1.1) Plastic-Cased ECU only**.
2. MIL circuit grounded between light and ECU.
   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuit 31.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuit 19.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuit 29.
3. ECU

*NOTE: MIL in Metal-Cased ECU systems is an LED. The MIL in Plastic-Cased ECU systems must be a 1/4 watt incandescent lamp.

Diagnostic Aid #4 "SPEED SENSOR" (MIL does not turn off during cranking). Indicates the ECU is not receiving a signal from the speed sensor.

Possible causes:
1. Speed sensor
2. Speed sensor circuit problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Pin circuits 3 and 21
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Pin circuits 9 and 10.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Pin circuits 9 and 10.
3. Speed sensor/toothed wheel air gap
4. Toothed wheel
5. Flywheel key sheared
6. ECU

Diagnostic Aid #5 "FUEL PUMP" (fuel pump not turning on)

Possible causes:
1. Fuel pump fuse
2. Fuel pump circuit problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Circuits 43, 44, and relay.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Circuits 30, 87, and relay.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Circuits 30, 87, and relay.
3. Fuel pump

Diagnostic Aid #6 "RELAY" (relay not operating)

Possible causes:
1. Safety switches/circuit(s) problem
   "35 Pin" (MA 1.7) Metal-Cased ECU: Circuits 41 and 41A.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Circuit 3.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Circuit 25.
2. Relay circuit(s) problem
   "**35 Pin" (MA 1.7) Metal-Cased ECU:** Circuits 28, 41, and 41A.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Circuits 18, 85, 30, and 87.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Circuits 28,85, 30, and 87.
3. Relay
4. ECU grounds
5. ECU

Diagnostic Aid #7 "IGNITION SYSTEM" (no spark)

Possible causes:
1. Spark plug
2. Plug wire
3. Coil
4. Coil circuit(s)
   "35 Pin" (MA 1.7) Metal-Cased ECU: Circuits 1, 19, 40, 40A, 43, and relay.
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Circuits 22, 23, 65, 66, 30, and relay.
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Circuits 30, 31, 65, 66, relay and relay circuit 30.
5. ECU grounds
6. ECU

5B

Diagnostic Aid #8 "FUEL SYSTEM-ELECTRICAL" (no fuel delivery)

Possible causes:
1. No fuel
2. Air in fuel rail
3. Fuel valve shut off
4. Fuel filter/line plugged
5. Injector circuit(s)
   "35 Pin" (MA 1.7) Metal-Cased ECU: Circuits 35, 35A, 45, and 45A
   "24 Pin" (MSE 1.0) Plastic-Cased ECU: Circuits 16, 17, 45, and 45A
   "32 Pin" (MSE 1.1) Plastic-Cased ECU: Circuits 14,15, and 45.
6. Injector
7. ECU grounds
8. ECU

Diagnostic Aid #9 "FUEL SYSTEM" (fuel pressure)

Possible causes for low fuel system pressure:
1. Low fuel
2. Fuel filter plugged
3. Fuel supply line plugged
4. Pressure regulator
5. Fuel pump

Possible causes for high fuel system pressure:
1. Pressure regulator
2. Fuel return line plugged or restricted.

Diagnostic Aid #10 "BASIC ENGINE" (cranks but will not run)

Possible causes:
1. Refer to basic engine troubleshooting charts within service manual sections 3, 5, and 8.

Section 6
Lubrication System

General

This engine uses a full pressure lubrication system. This system delivers oil under pressure to the crankshaft, camshaft and connecting rod bearing surfaces. In addition to lubricating the bearing surfaces, the lubrication system supplies oil to the hydraulic valve lifters.

A high-efficiency gerotor pump is located in the closure plate. The oil pump maintains high oil flow and oil pressure, even at low speeds and high operating temperatures. A pressure relief valve limits the maximum pressure of the system.

Service

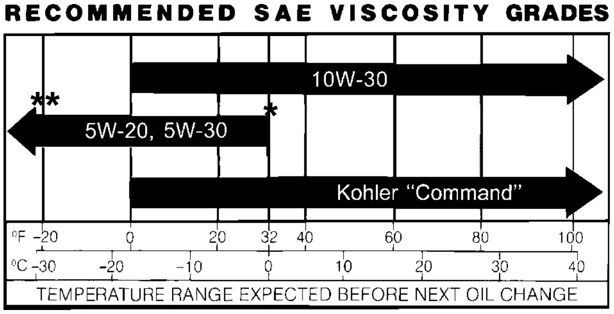
The closure plate must be removed to service the oil pickup, the pressure relief valve and the oil pump. Refer to the appropriate procedures in Sections 9 and 10.

Oil Recommendations

Using the proper type and weight of oil in the crankcase is extremely important; so is checking oil daily and changing the oil and filter regularly.

Use high-quality detergent oil of **API (American Petroleum Institute) service class SG, SH, SJ or higher.** Select the viscosity based on the air temperature at the time of operation as shown in the following table.

RECOMMENDED SAE VISCOSITY GRADES



*Use of synthetic oil having 5W-20 or 5W-30 rating is acceptable, up to 4°C (40°F).
**Synthetic oils will provide better starting in extreme cold below -23°C (-10°F).

NOTE: Using other than service class SG, SH, SJ or higher oil, or extending oil change intervals longer than recommended can cause engine damage.

NOTE: Synthetic oils meeting the listed classifications may be used with oil changes performed at the recommended intervals. However, to allow piston rings to properly seat, a new or rebuilt engine should be operated for at least 50 hours using standard petroleum based oil before switching to synthetic oil.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade. See Figure 6-1.

Figure 6-1. Oil Container Logo.

The top position of the symbol shows service class such as **API SERVICE CLASS SJ**. The symbol may show additional categories such as **SH, SG/CC, or CD**. The center portion shows the viscosity grade such as SAE 10W-30. If the bottom portion shows "Energy Conserving," it means that oil is intended to improve fuel economy in passenger car engines.

Checking Oil Level

The importance of checking and maintaining the proper oil level in the crankcase cannot be overemphasized. Check oil **BEFORE EACH USE** as follows:

1. Make sure the engine is stopped, level and is cool so the oil has had time to drain into the sump.

2. Clean the area around the dipstick before removing it. This will help to keep dirt, grass clippings, etc., out of the engine.

3. Remove the dipstick; wipe oil off. Reinsert the dipstick into the tube until fully seated. See Figure 6-2.

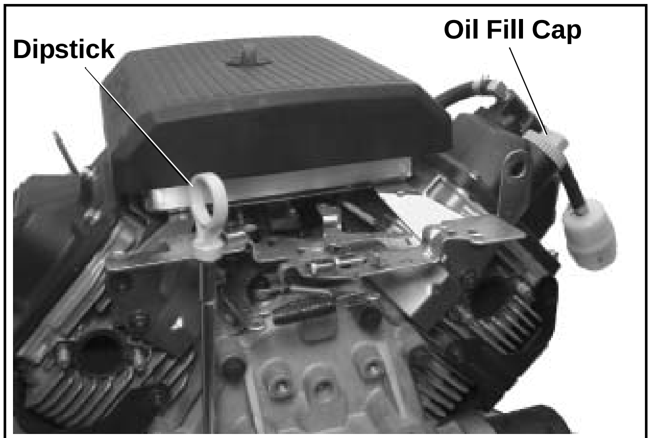


Figure 6-2. Location of Oil Fill Cap and Dipstick.

4. Remove dipstick and check oil level. The level should be between the ‘‘F’’ and ‘‘L’’ marks. If low, add oil of the proper type up to the "F" mark. Reinstall oil fill cap and dipstick.

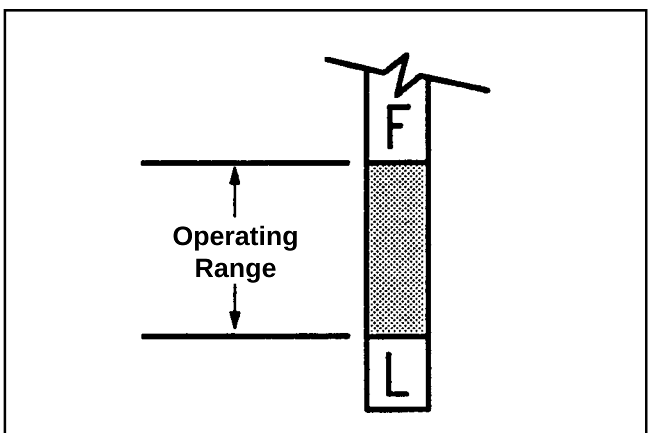


Figure 6-3. Oil Level Marks on Dipstick.

NOTE: To prevent extensive engine wear or damage, always maintain the proper oil level in the crankcase. Never operate the engine with the oil level below the ‘‘L’’ mark or above the ‘‘F’’ mark on the dipstick.

Changing Oil and Oil Filter

Changing Oil

Change the oil after every **100 hours** of operation (more frequently under severe conditions). Refill with service class SG, SH, SJ or higher oil as specified in the “Viscosity Grades” table on page 6.1.

Change the oil while the engine is still warm. The oil will flow more freely and carry away more impurities. Make sure the engine is level when filling or checking oil.

Change the oil as follows:

1. Clean the areas around one of the oil drain plugs, oil fill cap, and dipstick.

2. Remove one of the oil drain plugs. A drain plug is located on either side of the crankcase; one is adjacent to and below the oil filter, the other is below the starter. See Figure 6-4.

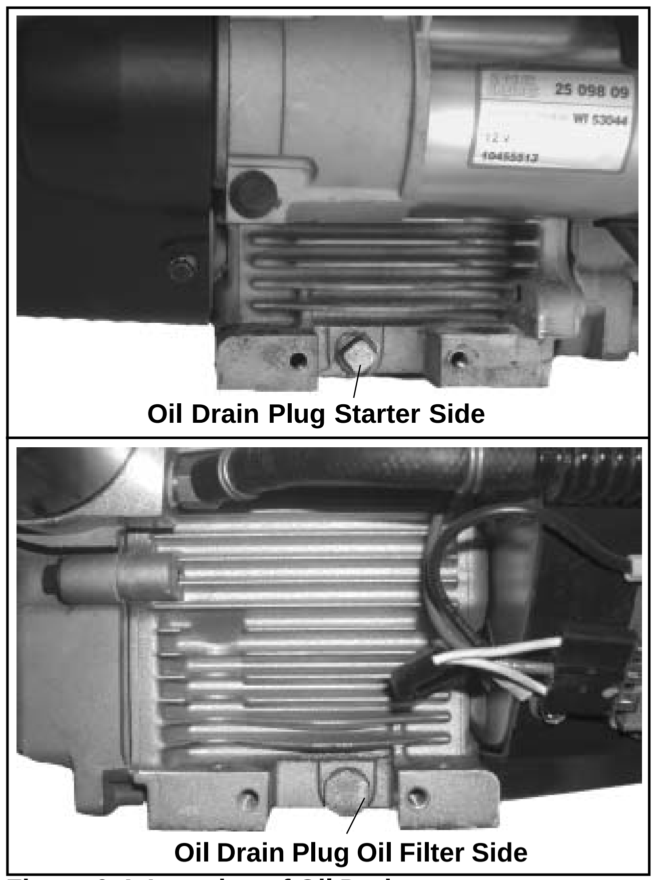


Figure 6-4. Location of Oil Drains.

3. Allow all the oil to drain and then reinstall the drain plug. Torque to **13.6 N·m (10 ft. lb.)**.

4. Remove the oil fill cap and fill the engine with the proper oil to the ‘‘F’’ mark on the dipstick. Always check the oil level with the dipstick before adding more oil.

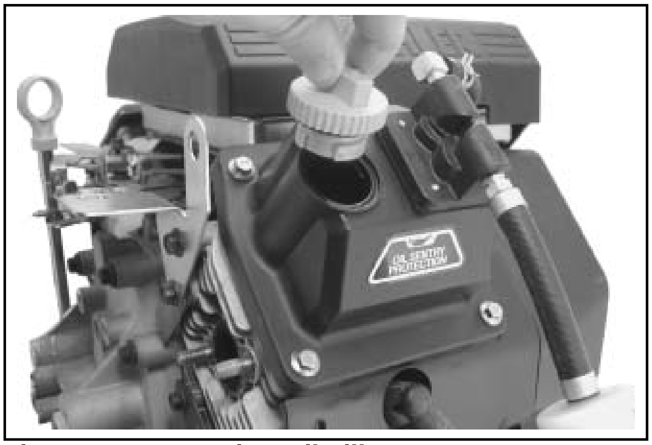


Figure 6-5. Removing Oil Fill Cap.

5. Reinstall the oil fill cap.

Changing Oil Filter
Replace the oil filter **at least every other oil change (every 200 hours of operation)**. Always use a genuine Kohler oil filter. Change the filter as follows. See Figure 6-6.

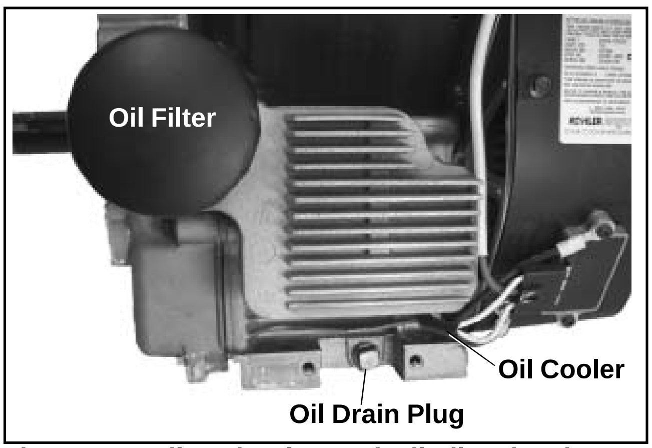


Figure 6-6. Oil Drain Plug and Oil Filter (engine with oil cooler).

1. Clean the areas around the drain plug, oil filter, oil fill cap and dipstick.

2. Remove one of the oil drain plugs. A drain plug is located on either side of the crankcase; one is adjacent to and below the oil filter, the other is below the starter.

3. Allow all oil to drain and then reinstall the drain plug. Torque to **13.6 N·m (10 ft. lb.)**.

4. Remove the old filter and wipe off the filter adapter with a clean cloth.

5. Place a new replacement filter in a shallow pan with the open end up. Pour new oil, of the proper type, in through the threaded center hole. Stop pouring when the oil reaches the bottom of the threads. Allow a minute or two for the oil to be absorbed by the filter material.

6. Apply a thin film of clean oil to the rubber gasket on the new filter.

7. Install the new oil filter to the filter adapter. Hand tighten the filter clockwise until the rubber gasket contacts the adapter, then tighten the filter an additional **2/3-1 turn**.

8. Remove the oil fill cap and fill the engine with the proper oil to the ‘‘F’’ mark on the dipstick. Always check the oil level with the dipstick before adding more oil.

9. Reinstall the oil fill cap and dipstick.

10. Start the engine and check for oil leaks. Stop the engine, correct any leaks, and allow a minute for the oil to drain down, then recheck the level on the dipstick.

Service Oil Cooler

Some engines are equipped with an oil cooler. One style of oil cooler mounts on the engine crankcase and has the oil filter on it. The other style of oil cooler is mounted on the blower housing, separate from the oil filter. See Figure 6-7.

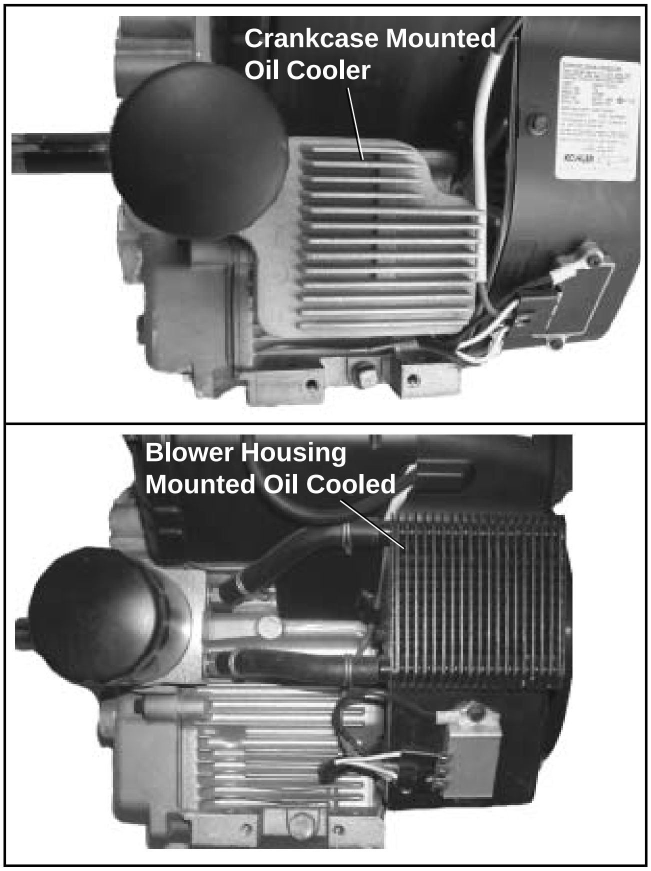


Figure 6-7. Oil Coolers.

Inspect and clean the oil cooler **every 100 hours of operation** (more frequently under severe conditions). In order to be effective, the oil cooler must be kept free of debris.

To service the crankcase mounted oil cooler, clean off the outside fins with a brush or with compressed air.

To service the blower housing mounted oil cooler, clean the outside of fins with a brush. Remove the two screws holding the cooler unit to the blower housing. Tilt the cooler downward. Clean the inside of the cooler with a brush or with compressed air. After cleaning, reinstall the oil cooler to the blower housing with the two mounting screws.

Oil Sentry™

General

Some engines are equipped with an optional Oil Sentry™ oil pressure monitor switch. See Figure 6-8. If the pressure drops below an acceptable level, the Oil Sentry™ will either shut off the engine or activate a warning signal, depending on the application.

The pressure switch is designed to break contact as the oil pressure increases above 3-5 psi, and make contact as the oil pressure decreases below 3-5 psi.

On stationary or unattended applications (pumps, generators, etc.), the pressure switch can be used to ground the ignition module to stop the engine. On vehicular applications (lawn tractors, mowers, etc.) the pressure switch can only be used to activate a “low oil” warning light or signal.

NOTE: Make sure the oil level is checked **before each use** and is maintained up to the “F” mark on the dipstick. This includes engines equipped with Oil Sentry™.

Installation

The Oil Sentry™ pressure switch is installed in the breather cover. See Figure 6-8.

Figure 6-8. Location of Oil Sentry™ Switch (or pipe plug).

On engines not equipped with Oil Sentry™ the installation hole is sealed with a 1/8-27 N.P.T.F. pipe plug.

To install the switch, follow these steps:

1. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent) to the threads of the switch.

2. Install the switch into the tapped hole in the breather cover. See Figure 6-8.

3. Torque the switch to **4.5 N·m (40 in. lb.)**.

Testing

Compressed air, a pressure regulator, pressure gauge and a continuity tester are required to test the switch.

1. Connect the continuity tester across the blade terminal and the metal case of the switch. With **0 psi** pressure applied to the switch, the tester should indicate **continuity (switch closed)**.

2. Gradually increase the pressure to the switch. As the pressure increases through the range of **3.0/5.0 psi** the tester should indicate a change to **no continuity (switch open)**. The switch should remain open as the pressure is increased to **90 psi maximum**.

3. Gradually decrease the pressure through the range of **3.0/5.0 psi** The tester should indicate a change to **continuity (switch closed) down to 0 psi**.

4. Replace the switch if it does not operate as specified.

Section 7
Retractable Starter

WARNING: Spring Under Tension!
Retractable starters contain a powerful, recoil spring that is under tension. Always wear safety goggles when servicing retractable starters and carefully follow instructions in this section for relieving spring tension.

To Remove Starter
1. Remove the five hex. flange screws securing the starter to the blower housing.

2. Remove the starter.

To Install Starter
1. Install the retractable starter onto the blower housing, leaving the five hex. flange screws slightly loose.

2. Pull the starter handle out until the pawls engage in the drive cup. Hold the handle in this position and tighten the screws securely.

Rope Replacement
The rope can be replaced without complete starter disassembly.

1. Remove the starter from the blower housing.

2. Pull the rope out approximately 12 in. and tie a temporary (slip) knot in it to keep it from retracting into the starter. See Figure 7-2.

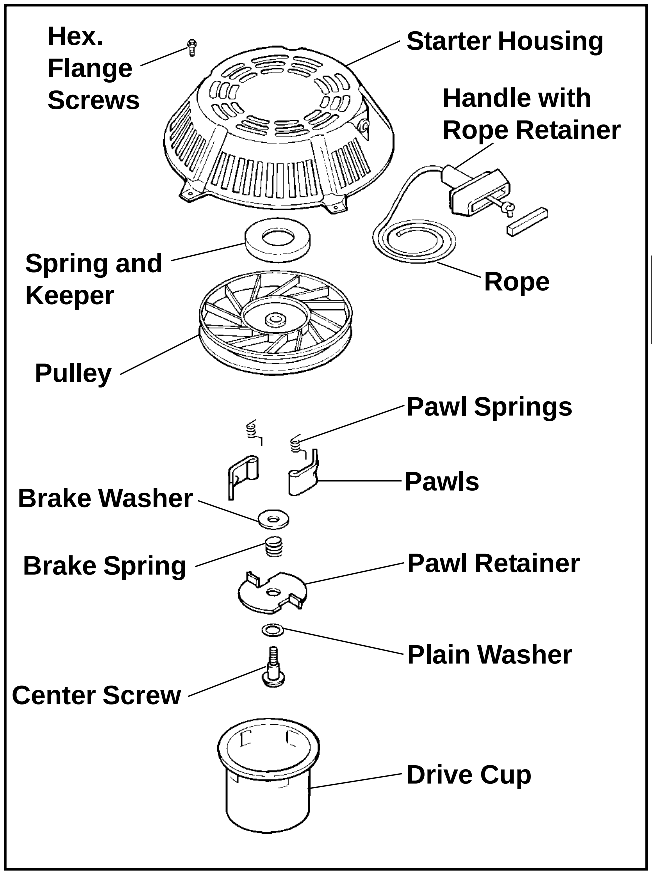


Figure 7-1. Retractable Starter - Exploded View.

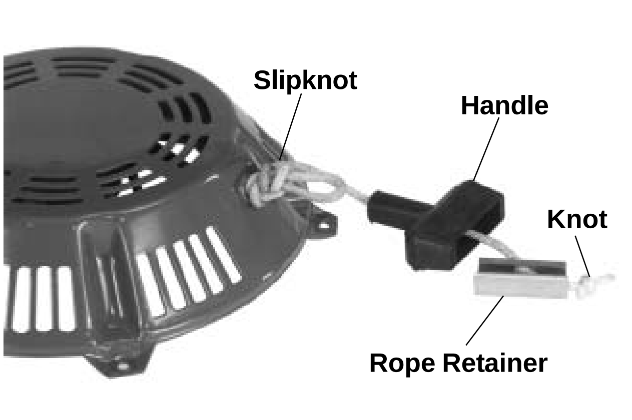


Figure 7-2. Removing Starter Handle.

3. Remove the rope retainer from inside the starter handle. Untie the single knot and remove the rope retainer and handle.

4. Hold the pulley firmly and untie the slipknot. Allow the pulley to rotate slowly as the spring tension is released.

5. When all spring tension on the starter pulley is released, remove the rope from the pulley.

6. Tie a single knot in one end of the new rope.

7. Rotate the pulley counterclockwise (when viewed from pawl side of pulley) until the spring is tight (approximately 6 full turns of pulley).

8. Rotate the pulley clockwise until the rope hole in the pulley is aligned with the rope guide bushing of the starter housing.

   NOTE: Do not allow the pulley/spring to unwind. Enlist the aid of a helper if necessary, or use a C-clamp to hold the pulley in position.

9. Insert the new rope through the rope hole in the starter pulley and the rope guide bushing of the housing. See Figure 7-3.

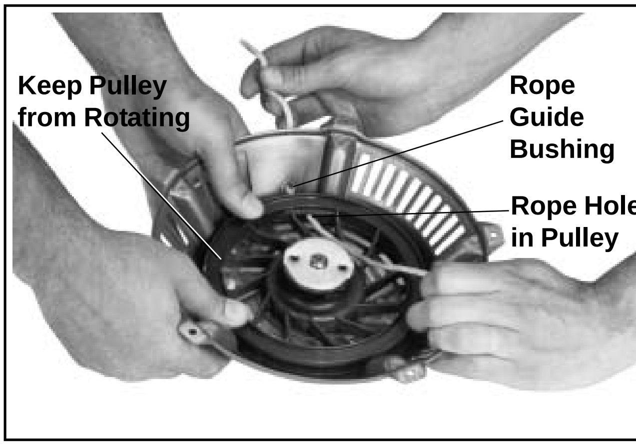


Figure 7-3. Installing Rope.

10. Tie a slipknot approximately 12 in. from the free end of rope. Hold the pulley firmly and allow it to rotate slowly until the slipknot reaches the guide bushing of the housing.

11. Slip the handle and rope retainer onto the rope. Tie a single knot at the end of the rope. Install the rope retainer into the starter handle.

12. Untie the slipknot and pull on the handle until the rope is fully extended. Slowly retract the rope into the starter. When the spring is properly tensioned, the rope will retract fully and the handle will stop against the starter housing.

Pawls (Dogs) Replacement

To replace the pawls, follow disassembly steps 1-4 and reassembly steps 3-8 on the following pages. A pawl repair kit is available which includes the following components:

Qty.	Description
1	Pawl Retainer
1	Center Screw
2	Pawl (Dog) Spring
1	Brake Spring
2	Starter Pawl (Dog)
1	Brake Washer
1	Washer

Disassembly

WARNING: Spring Under Tension!
Do not remove the center screw from the starter until the spring tension is released. Removing the center screw before releasing spring tension, or improper starter disassembly, can cause the sudden and potentially dangerous release of the spring. Follow these instructions carefully to ensure personal safety and proper starter disassembly. Make sure adequate face protection is worn by all persons in the area.

1. Release the spring tension and remove the handle and the starter rope. (Refer to “Rope Replacement,” steps 2 through 5 on pages 7.1 and 7.2.)
2. Remove the center screw, washer, and pawl retainer. See Figure 7-4.
3. Remove the brake spring and the brake washer. See Figure 7-5.
4. Carefully note the positions of the pawls and pawl springs before removing them.

   Remove the pawls and pawl springs from the starter pulley.

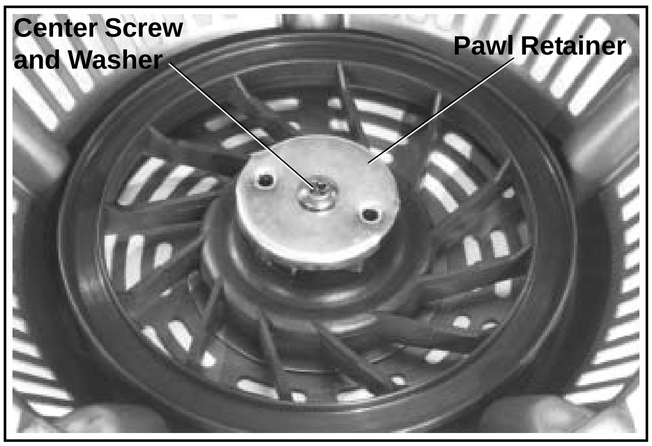


Figure 7-4. Center Screw, Washer and Pawl Retainer.

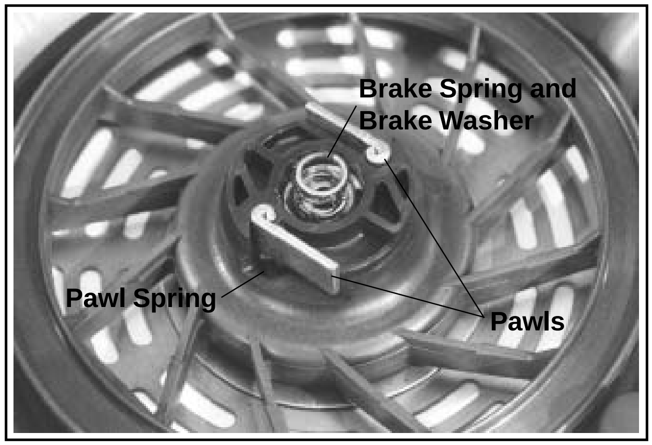


Figure 7-5. Brake Spring and Washer, Pawls, and Pawl Springs.

5. Rotate the pulley **clockwise 2 full turns**. This will ensure the spring is disengaged from the starter housing.
6. Hold the pulley in the starter housing. Invert the pulley/housing so the pulley is away from your face, and away from others in the area.
7. Rotate the pulley slightly from side to side and carefully separate the pulley from the housing. See Figure 7-6.

   If the pulley and the housing do not separate easily, the spring could be engaged in the starter housing, or there is still tension on the spring. Return the pulley to the housing and repeat step 5 before separating the pulley and housing.

Figure 7-6. Removing Pulley from Housing.

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8. Note the position of the spring and keeper assembly in the pulley. See Figure 7-7.

   Remove the spring and keeper assembly from the pulley as a package.

WARNING: Spring Under Tension!
Do not remove the spring from the keeper. Severe personal injury could result from the sudden uncoiling of the spring.

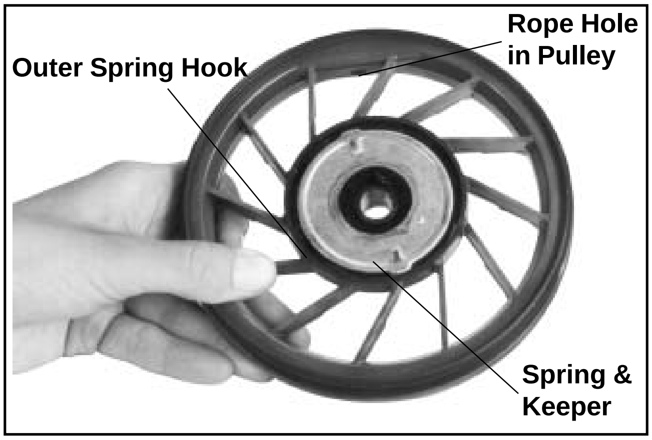

Figure 7-7. Position of Spring and Keeper in Pulley.

Inspection and Service

1. Carefully inspect the rope, pawls, housing, center screw, and other components for wear or damage.

2. Replace all worn or damaged components. Use only genuine Kohler replacement parts as specified in the Parts Manual. All components shown in Figure 7-1 are available as service parts. Do not use nonstandard parts.

3. Do not attempt to rewind a spring that has come out of the keeper. Order and install a new spring and keeper assembly.

4. Clean all old grease and dirt from the starter components. Generously lubricate the spring and center shaft with any commercially available bearing grease.

Reassembly

1. Make sure the spring is well lubricated with grease. Place the spring and keeper assembly inside the pulley (with spring towards pulley). See Figure 7-7.

2. Install the pulley assembly into the starter housing. See Figure 7-8. Make sure the pulley is fully seated against the starter housing. Do not wind the pulley and recoil spring at this time.

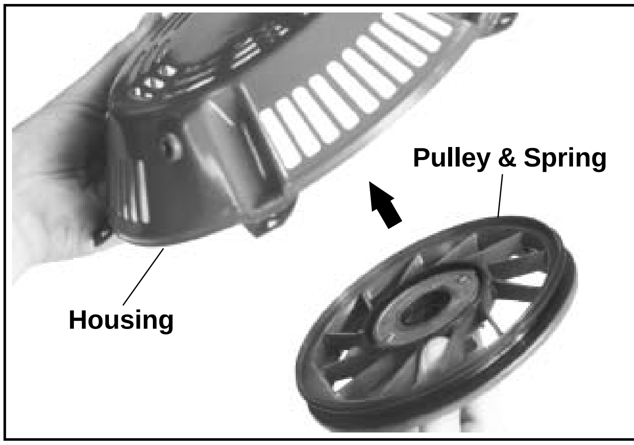

Figure 7-8. Installing Pulley and Spring into Housing.

3. Install the pawl springs and pawls into the starter pulley. See Figure 7-9.

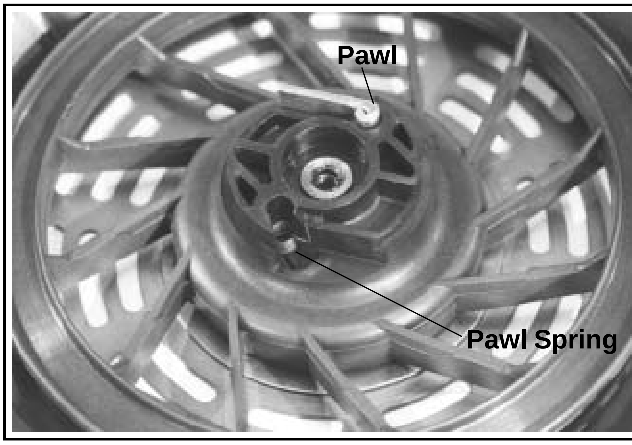

Figure 7-9. Installing Pawls and Pawl Springs.

4. Place the brake washer in the recess in starter pulley; over the center shaft.

5. Lubricate the brake spring sparingly with grease. Place the spring on the plain washer. Make sure the threads in the center shaft remain clean, dry, and free of grease and oil.

6. Apply a small amount of **Loctite® No. 271** to the threads of the center screw. Install the center screw, with the washer and retainer, to the center shaft. Torque the screw to **7.4-8.5 N·m (65-75 in. lb.)**.

7. Tension the spring and install the rope and handle as instructed in steps 6 through 12 under "Rope Replacement" on page 7.2.

8. Install the starter to the engine blower housing as instructed in "To Install Starter" on page 7.1.

Section 8
Electrical System and Components

This section covers the operation, service and repair of the electrical system components. Systems and components covered in this section are:

- Spark Plugs
- Battery and Charging System
- Electronic CD Ignition System (including SMART-SPARK™ on applicable models)
- Electric Starter

Spark Plugs

Engine misfire or starting problems are often caused by a spark plug that has improper gap or is in poor condition.

The engine is equipped with the following spark plugs:

Type: The standard spark plug is a Champion® RC12YC (Kohler Part No. 12 132 02-S). A high-performance spark plug, Champion® Platinum 3071 (used on Pro Series engines, Kohler Part No. 25 132 12-S) is also available. Equivalent alternate brand plugs can also be used.

Gap: 0.76 mm (0.030 in.)
Thread Size: 14 mm
Reach: 19.1 mm (3/4 in.)
Hex. Size: 15.9 mm (5/8 in.)

Spark Plug Service

Every **200 hours** of operation, remove each spark plug. Check its condition and either reset the gap or replace with a new plug as necessary. To service the plugs, perform the following steps:

1. Before removing each spark plug, clean the area around the base of the plug to keep dirt and debris out of the engine.

2. Remove the plug and check its condition. See “Inspection” following this procedure. Replace the plug if necessary.

NOTE: Do not clean spark plug in a machine using abrasive grit. Some grit could remain in the spark plug and enter the engine causing extensive wear and damage.

3. Check the gap using a wire feeler gauge. Adjust the gap to **0.76 mm (0.030 in.)** by carefully bending the ground electrode. See Figure 8-1.

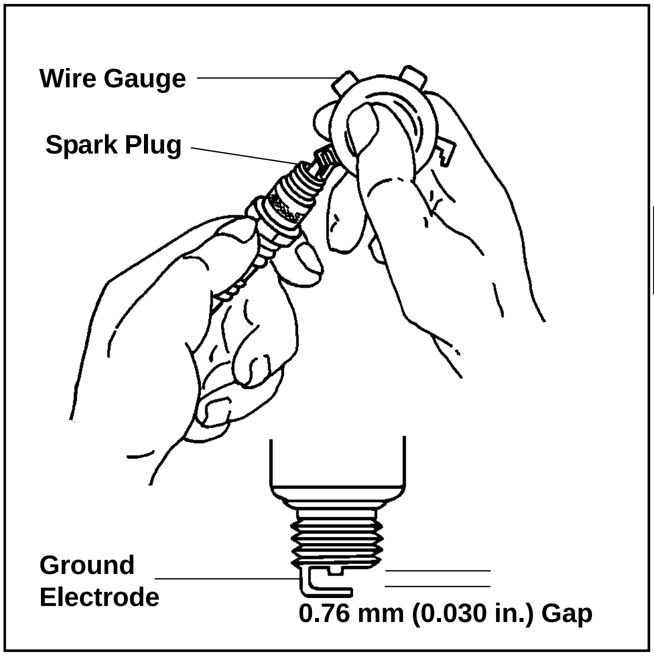

Figure 8-1. Servicing Spark Plug.

4. Reinstall the spark plug into the cylinder head and torque to **24.4-29.8 N·m (18-22 ft. lb.)**.

Inspection

Inspect each spark plug as it is removed from the cylinder head. The deposits on the tip are an indication of the general condition of the piston rings, valves, and carburetor.

Normal and fouled plugs are shown in the following photos:

Normal: A plug taken from an engine operating under normal conditions will have light tan or gray colored deposits. If the center electrode is not worn, a plug in this condition could be set to the proper gap and reused.

Carbon Fouled: Soft, sooty, black deposits indicate incomplete combustion caused by a restricted air cleaner, over rich carburetion, weak ignition, or poor compression.

Worn: On a worn plug, the center electrode will be rounded and the gap will be greater than the specified gap. Replace a worn spark plug immediately.

Wet Fouled: A wet plug is caused by excess fuel or oil in the combustion chamber. Excess fuel could be caused by a restricted air cleaner, a carburetor problem, or operating the engine with too much choke. Oil in the combustion chamber is usually caused by a restricted air cleaner, a breather problem, worn piston rings or valve guides.

Overheated: Chalky, white deposits indicate very high combustion temperatures. This condition is usually accompanied by excessive gap erosion. Lean carburetor settings, an intake air leak, or incorrect spark timing are normal causes for high combustion temperatures.

Battery

General

A 12-volt battery with 400 cold cranking amps is generally recommended for starting in all conditions. A smaller capacity battery is often sufficient if an application is started only in warmer temperatures. Refer to the following table for minimum capacities (cca) based on anticipated ambient temperatures. The actual cold cranking requirement depends on engine size, application and starting temperatures. The cranking requirements increase as temperatures decrease and battery capacity shrinks. Refer also to the operating instructions of the equipment being this engine powers for specific battery requirements.

Battery Size Recommendations

Temperature	Battery Required
Above 32°F (0°C)	200 cca minimum
0°F to 32°F (-18°C to 0°C)	250 cca minimum
-5°F to 0°F (-21°C to -18°C)	300 cca minimum
-10°F (-23°C) or below	400 cca minimum

If the battery charge is insufficient to turn over the engine, recharge the battery.

Battery Maintenance

Regular maintenance is necessary to prolong battery life.

WARNING: Explosive Gas!

Batteries produce explosive hydrogen gas while being charged. To prevent a fire or explosion, charge batteries only in well ventilated areas. Keep sources of ignition away from the battery at all times. Keep batteries out of the reach of children. Remove all jewelry when servicing batteries.

Before disconnecting the negative (-) ground cable, make sure all switches are OFF. If ON, a spark will occur at the ground cable terminal which could cause an explosion if hydrogen gas or gasoline vapors are present.

1. Regularly check the level of electrolyte. Add distilled water as necessary to maintain the recommended level.

   NOTE: Do not overfill the battery. Poor performance or early failure due to loss of electrolyte will result.

2. Keep the cables, terminals, and external surfaces of the battery clean. A build-up of corrosive acid or grime on the external surfaces can cause the battery to self-discharge. Self-discharge occurs rapidly when moisture is present.

3. Wash the cables, terminals, and external surfaces with a mild baking soda and water solution. Rinse thoroughly with clear water.

   NOTE: Do not allow the baking soda solution to enter the cells as this will destroy the electrolyte.

Battery Test

To test the battery, you will need a DC voltmeter. Perform the following steps (see Figure 8-2):

1. Connect the voltmeter across the battery terminals.

2. Crank the engine. If the battery drops below 9 volts while cranking, the battery is too small, discharged, or faulty.

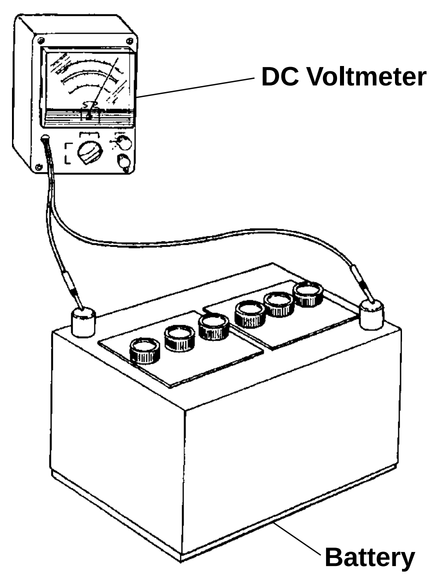

Figure 8-2. Battery Voltage Test.

8

Electronic CD Ignition Systems

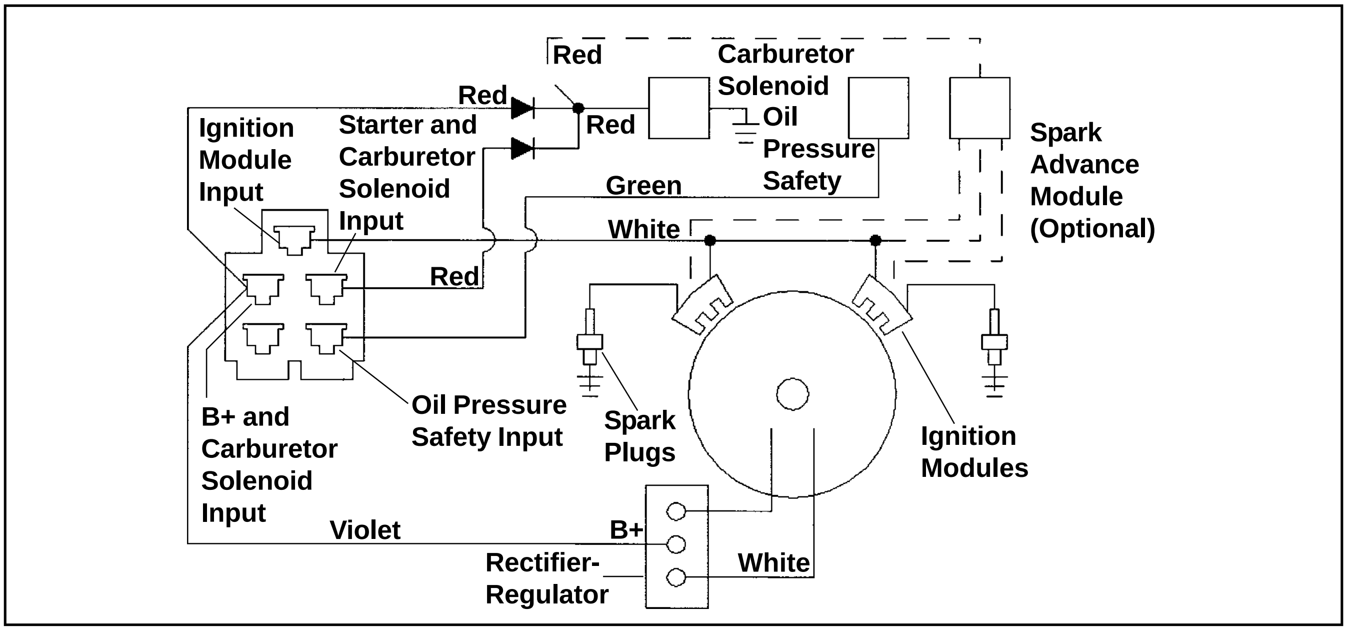

Figure 8-3. Electronic CD Ignition System (For Customer Connected Tractor Applications).

The SMART-SPARK™ ignition system used on some models is an advanced version of the CD ignition system used on other CH engines. Its operation can be best understood by first understanding the standard system and how it works. Since both systems will continue in use, it is advantageous to understand them both. The operation of the standard system is explained first then expanded to cover SMART-SPARK™.

Operation of CD Ignition Systems

A. Capacitive Discharge with Fixed Timing

This system (Figure 8-3) consists of the following components:

- A magnet assembly which is permanently affixed to the flywheel.
- Two electronic capacitive-discharge ignition modules which mount on the engine crankcase (Figure 8-4).
- A kill switch (or key switch) which grounds the modules to stop the engine.
- Two spark plugs.

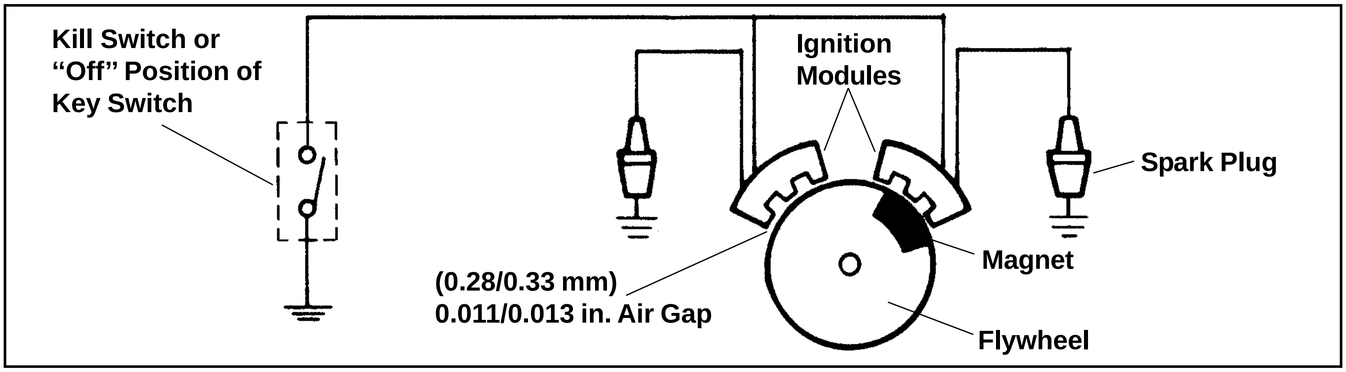

Figure 8-4. Capacitive Discharge (Fixed Timing) Ignition System.

The timing of the spark is controlled by the location of the flywheel magnet group as referenced to engine top dead center.

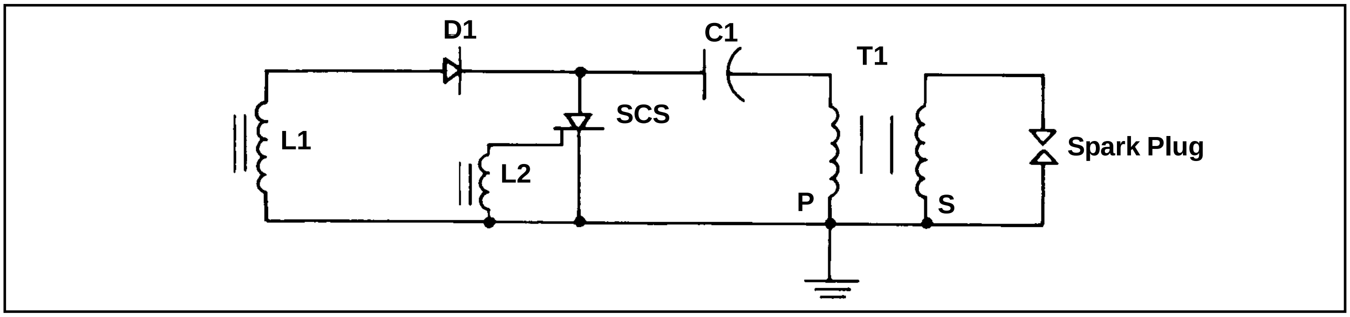

Figure 8-5. Capacitive Discharge Ignition Module Schematic.

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Operation: As the flywheel rotates, the magnet grouping passes the input coil (L1). The corresponding magnetic field induces energy into the input coil (L1). The resultant pulse is rectified by D1 and charges capacitor C1. As the magnet assembly completes its pass, it activates the triggering device (L2), which causes the semiconductor switch (SCS) to turn on. With the device switch "ON," the charging capacitor (C1) is directly connected across the primary (P) of the output transformer (T1). As the capacitor discharges, the current initiates a fast rising flux field in the transformer core. A high voltage pulse is generated from this action into the secondary winding of the transformer. This pulse is delivered to the spark plug gap. Ionization of the gap occurs, resulting in an arc at the plug electrodes. This spark ignites the fuel-air mixture in the combustion chamber.

B. Capacitive Discharge with Electronic Spark Advance (SMART-SPARK™).

SMART-SPARK™ equipped engines utilize an electronic capacitive discharge ignition system with electronic spark advance. A typical application (Figure 8-6) consists of the following components:

- A magnet assembly which is permanently affixed to the flywheel.
- Two electronic capacitive discharge ignition modules which mount on the engine crankcase (Figure 8-6).
- A spark advance module which mounts to the engine shrouding (Figure 8-7).
- A 12 volt battery which supplies current to the spark advance module.
- A kill switch (or key switch) which grounds the spark advance module to stop the engine.
- Two spark plugs.

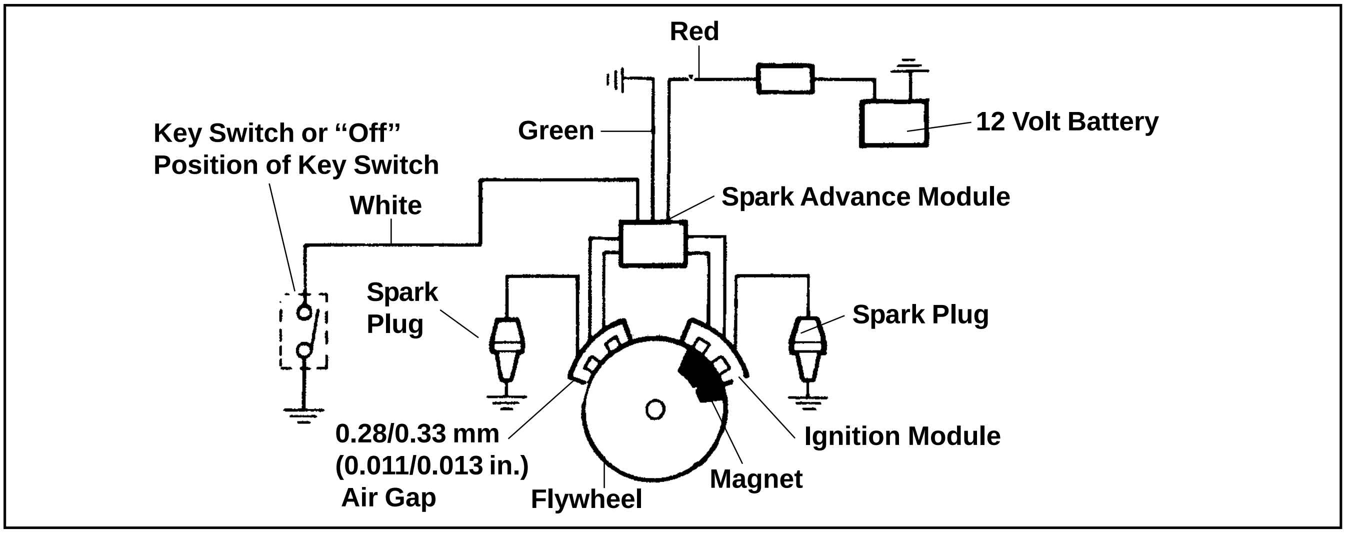

Figure 8-6. Capacitive Discharge Ignition System with Spark Advance.

The timing of the spark is controlled by the location of the flywheel magnet group as referenced to the engine top dead center and the delay created by the spark advance module.

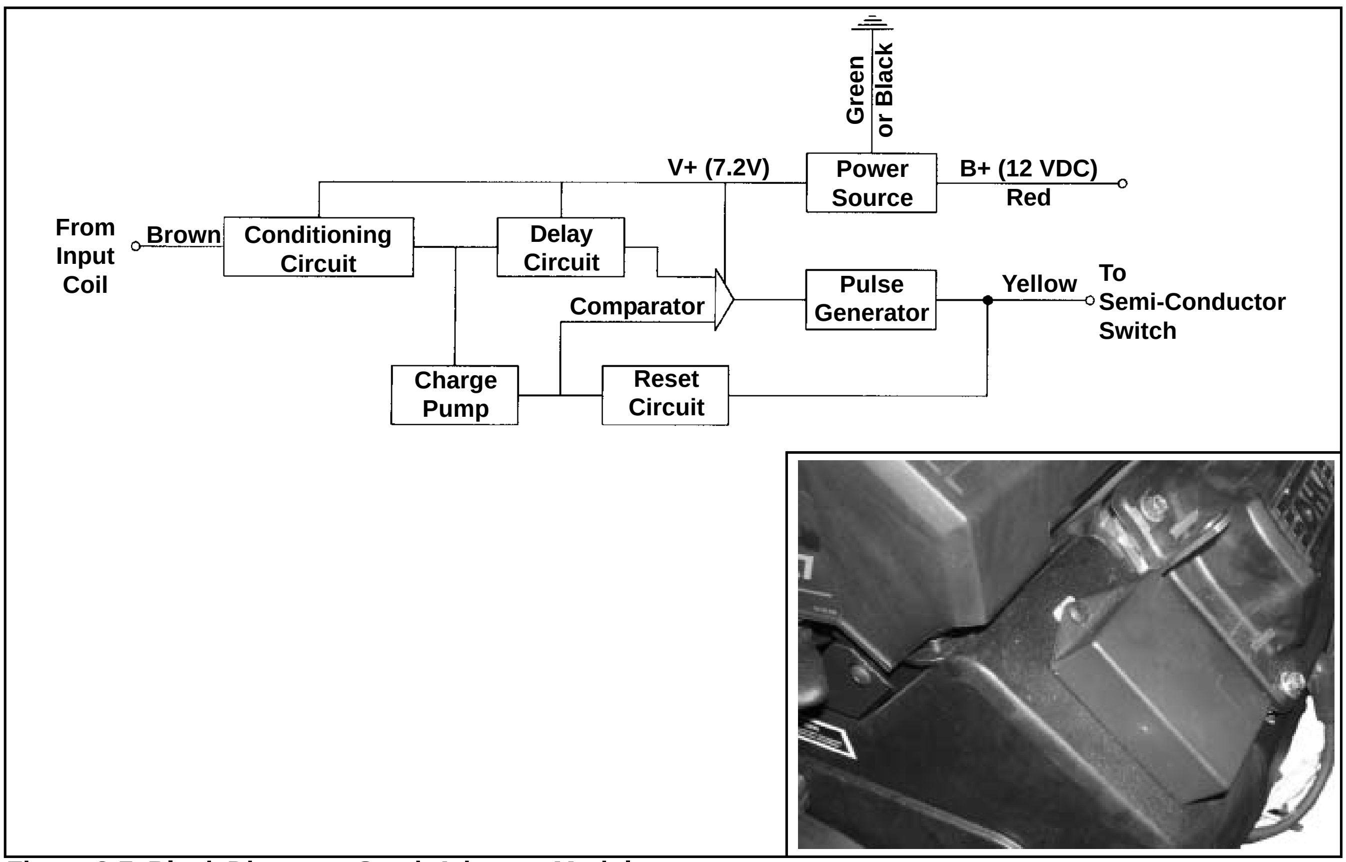

Figure 8-7. Block Diagram - Spark Advance Module.

Operation: The ignition module for this system operates in the same fashion as the fixed timing module, except the trigger circuit for the semiconductor (L2, Figure 8-5) is replaced by the spark advance module (Figure 8-7).

The pulse generated by the input coil of the ignition module (L1, Figure 8-5) is fed to the input of the conditioning circuit. The conditioning circuit shapes this pulse, putting it in a useable form for the additional circuits. This pulse starts the charge pump, which charges a capacitor in a linear fashion that can be directly related to the engine speed. At the same time the pulse resets the delay circuit for length of the pulse width. The comparator is off during this period and no output is generated. As soon as the original pulse drops back to zero, the capacitor in the delay circuit begins to charge.

When the charge on the delay capacitor exceeds the charge on the charge pump capacitor the comparator changes state, activating the pulse generator. This pulse turns "ON" the CD ignition module semiconductor. Energy is then transferred to the secondary of the output transformer (T1, Figure 8-5). The high voltage pulse generated here is delivered to the spark plug, causing arcing of the spark gap and igniting the fuel-air mixture in the combustion chamber. As the trigger pulse is generated, all associated circuits are reset, their capacitors discharged. The longer it takes the delay circuit to surpass the charge pump capacitor voltage, the later the trigger pulse will occur, retarding the timing accordingly.

Troubleshooting CD Ignition Systems
The CD ignition systems are designed to be trouble free for the life of the engine. Other than periodically checking/replacing the spark plugs, no maintenance or timing adjustments are necessary or possible. Mechanical systems do occasionally fail or break down, however, so the following troubleshooting information is provided to help you get to the root of a reported problem.

CAUTION: High-Energy Electric Spark!
The CD ignition systems produce a high-energy electric spark, but the spark must be discharged, or damage to the system can result. Do not crank or run an engine with a spark plug lead disconnected. Always provide a path for the spark to discharge to ground.

Reported ignition problems are most often due to poor connections. Before beginning the test procedure, check all external wiring. Be certain all ignition-related wires are connected, including the spark plug leads. Be certain all terminal connections fit snugly. Make sure the ignition switch is in the run position.

NOTE: The CD ignition systems are sensitive to excessive load on the kill lead. If a customer complains of hard starting, low power, or misfire under load, it may be due to excessive draw on the kill circuit. Perform the appropriate test procedure.

Test Procedure for Standard (Fixed Timing) CD Ignition System
Isolate and verify the trouble is within the engine ignition system.

1. Locate the plug connectors where the wiring harnesses from the engine and equipment are joined. Separate the connectors and remove the white "kill" lead from the engine connector. Rejoin the connectors and position or insulate the kill lead terminal so it cannot touch ground. Try to start** the engine to verify whether the reported problem is still present.

   a. If the problem is gone, the electrical system on the unit is suspect. Check the key switch, wires, connections, safety interlocks, etc.

   b. If the problem persists the condition is associated with the ignition or electrical system of the engine. Leave the kill lead isolated until all testing is completed.

**NOTE: If the engine starts or runs during any of the testing, you may need to ground the kill lead to shut it down. Because you have interrupted the kill circuit, it may not stop using the switch.

2. Test for spark on both cylinders with Kohler ignition tester, SPX Part No. KO1046 (formerly Kohler Part No. 24 455 02-S). Disconnect one spark plug lead and connect it to the post terminal of the tester. Connect the clip to a good ground, not to the spark plug. Crank the engine and observe the tester spark gap. Repeat the procedure on the other cylinder. Remember to reconnect the first spark plug lead.

   a. If one side is not firing, check all wiring, connections, and terminations on that side. If wiring is okay, replace ignition module and retest for spark.

   b. If the tester shows spark, but the engine misses or won't run on that cylinder, try a new spark plug.

c. If neither side is firing, recheck position of ignition switch and check for shorted kill lead.

Test Procedure for SMART-SPARK$_{TM}$ Ignition Systems

The following procedures are provided for troubleshooting ignition problems on SMART-SPARK$_{TM}$ equipped engines. They will allow you to isolate and pinpoint the failed component(s).

Special Tools Required:
- Hand Tachometer
- Tester* (SPX Part No. KO1046 formerly Kohler Part No. 24 455 02-S)
- Automotive timing light
- Multi-meter (digital)

Specifications Required:
- Spark plug gap 0.76 mm (0.030 in.)
- Ignition module air gap 0.28/0.33 mm (0.011-0.013 in.), 0.30 mm (0.012 in.) nominal

*NOTE: Ignition tester (SPX Part No. KO1046 formerly Kohler Part No. **24 455 02-S**) **must** be used to test ignition on these engines. Use of any other tester can result in inaccurate findings. Battery on unit **must** be fully charged and properly connected before making any of these tests (a battery that is hooked up or charged backward will crank the engine, but it won't have spark). Be sure drive is in neutral and all external loads are disconnected.

Test 1 – Isolate and verify the trouble is within the engine ignition system

1. Locate the plug connectors where the wiring harnesses from the engine and equipment are joined. Separate the connectors and remove the white "kill" lead from the engine connector. Rejoin the connectors and position or insulate the kill lead terminal so it cannot touch ground. Try to start** the engine to verify whether the reported problem is still present.

   a. If the problem is gone, the electrical system on the unit is suspect. Check the key switch, wires, connections, safety interlocks, etc.

   b. If the problem persists the condition is associated with the ignition or electrical system of the engine. Leave the kill lead isolated until all testing is completed.

**NOTE: If the engine starts or runs during any of the testing, you may need to ground the kill lead to shut it down. Because you have interrupted the kill circuit, it may not stop using the switch.

Test 2 – Test for spark

1. With the engine stopped, disconnect one spark plug lead. Connect the spark plug lead to post terminal of spark tester SPX Part No. KO1046 (formerly Kohler Part No. 24 455 02-S), and attach tester clip to a good engine ground.

NOTE: If two testers are available, testing can be performed simultaneously for both cylinders. However, if only one tester is available, two individual tests must be performed. The side not being tested must have the spark plug lead connected or grounded. **Do not** crank the engine or perform tests with one spark plug lead disconnected and not grounded or permanent system damage may occur.

2. Crank the engine over, establishing a minimum of **550-600 RPM**, and observe tester(s) for spark.

3. On a twin cylinder engine, repeat the spark test on the opposite cylinder if cylinders are being tested individually.

   a. If both cylinders have good spark, but the engine runs poorly, install new spark plugs gapped at **0.76 mm (0.030 in.)**, and retest engine performance. If problem persists, go to Test 3.

   b. If one cylinder had good spark, but the other cylinder had no spark or intermittent spark, go to Test 3.

   c. If there was no spark or intermittent spark on both cylinders, go to Test 4.

Test 3 – Check for timing advance

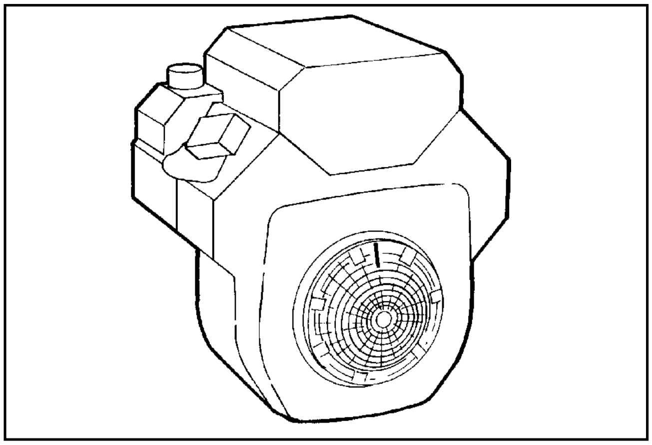

Figure 8-8.

1. Make a line near the edge of the flywheel screen with a marking pen or narrow tape.

2. Connect an automotive timing light to cylinder that had good spark.

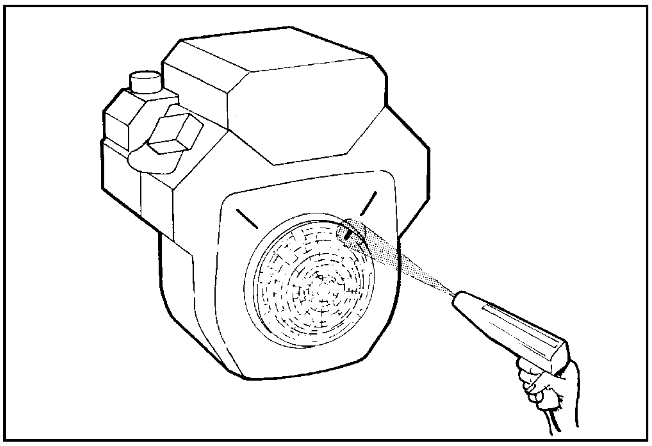

Figure 8-9.

3. Run the engine at idle and use the timing light beam to locate the line on the screen. Draw a line on the blower housing adjacent to the line on the screen. Accelerate to full throttle and watch for movement of the line on the screen relative to the line on the blower housing. If both cylinders had good spark, repeat the test on the other cylinder.

   a. If the line on the screen moved away from the line on the blower housing during acceleration, the SAM is working properly. If it didn't move away, go to Test 5.

   b. If you were able to check timing on both cylinders, the lines you made on the blower housing should be 90° apart. If they're not, go to Test 4.

Test 4 – Test the ignition modules and connections

1. Remove the blower housing from the engine. Inspect the wiring for any damage, cuts, bad crimps, loose terminals or broken wires.

2. Disconnect the leads from the ignition module(s) and clean all of the terminals (male and female) with aerosol electrical contact cleaner to remove any old dielectric compound, dark residue, dirt, or contamination. Disconnect the spark plug leads from the spark plugs.

3. Remove one of the mounting screws from each of the ignition modules. If the mounting screws are black, remove them both and discard. Replace them with part number M-561025-S. Look in the mounting hole with a flashlight and use a small round wire brush to remove any loose rust from the laminations inside the mounting hole.

4. Refer to the chart on page 8.10 to identify which ignition module(s) you have. If they are the smaller style, check the vendor part number on the face. All modules with vendor part numbers MA-2, MA-2A, or MA-2B (Kohler Part No. 24 584 03) should be replaced with 24 584 11 or 24 584 15-S. For small modules with vendor numbers MA-2C or MA-2D (Kohler Part No. 24 584 11), or the larger style modules (24 584 15-S and 24 584 36-S), use a digital ohmmeter to check the resistance values and compare them to the table following. When testing resistance to the laminations, touch the probe to the laminations inside the screw hole, as some laminations have a rust preventative coating on the surface which could alter the resistance reading.

   a. If all of the resistance values are within the ranges specified in the table, go to step 5.

   b. If any of the resistance values are not within the ranges specified in the table,[#] that module is faulty and must be replaced.

[#]NOTE: The resistance values apply only to modules that have been on a running engine. New service modules may have higher resistance until they have been run.

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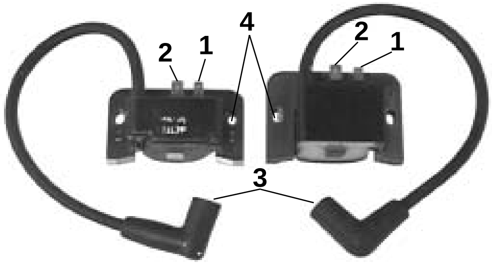
Ignition Module Resistance Table

24 584 03 or 24 584 11 (1 11/16 in. H) | **24 584 15-S or 24 584 36-S** (2 1/16 in. H)



Test (Use Digital Ohmmeter)	24 584 03 24 584 11 (1 11/16 in. H)	24 584 15-S (2 1/16 in. H)	24 584 36-S (2 1/16 in. H)
From No. 1 to 4	945 to 1175 ohms	890 to 1175 ohms	590 to 616 ohms
From No. 2 to 4	149 to 166 ohms	119 to 136 ohms	183 to 208 ohms
From No. 3 to 4	3750 to 7000 ohms	5600 to 9000 ohms	8000 to 40,000 ohms

5. Check and/or adjust the ignition module air gap(s). An air gap of **0.28/0.33 mm (0.011/0.013 in.) must** be maintained under all three legs of the ignition module(s). Checking/ adjusting should be performed with the parts at room temperature.

   a. If the module was not loosened or replaced, check that the specified air gap is present under all three legs. If the gap is correct, reinstall the second mounting screw removed earlier and recheck gap after tightening.

   b. If the gap is incorrect, or the module was loosened or replaced, adjust the gap as follows.

      1) Turn the flywheel magnet away from the module position.

      2) Attach the module to the mounting legs, pull it away from the flywheel, and snug the screws to hold it temporarily.

      3) Rotate the flywheel so the magnet is centered under the module.

      4) Position a **0.33 mm (0.013 in.)** feeler gauge between the magnet and all three legs of the module. The ignition module air gap is critical to proper system performance. **Do not** attempt to set it with a business card or folded microfiche card, use the feeler gauge specified. A **0.33 mm (0.013 in.)** feeler gauge is recommended because the gap has a tendency to close slightly as the module mounting screws are tightened.

      5) Loosen the mounting screws, allow the magnet to pull the module down against the feeler gauge, and retighten the mounting screws.

      6) Rotate the flywheel to remove the feeler gauge, position the magnet back under the module, and recheck that the specified gap, **minimum of 0.28 mm (0.011 in.)** exists under each leg of the module. When you are certain the gap is correct, torque the module mounting screws to **4.0 N·m (35 in. lb.)**. On a twin cylinder engine, repeat these 6 steps to set the opposite side ignition module.

6. Reattach the lead wires to the ignition module(s), noting if resistance is felt, indicating a snug fit between the male and female terminals. If any connections do not feel snug, disconnect the lead, lightly pinch the female terminal with a pliers, and recheck the fit.

7. When the integrity of all connections has been verified, repeat the spark test (Test 2).

   a. If a strong, steady spark is now present (both sides on a twin), your problem should be corrected. Go to step 4 of Test 5.

   b. If there is still a spark problem, perform all of Test 5.

Test 5 – Test the SAM

1. Trace the red power source lead from the SAM to the harness connection. Separate the connector and connect the red lead of a DC voltmeter to the harness terminal. Trace the ground lead from the SAM (black on singles, green on twins) to the grounding screw. Connect the black voltmeter lead to the eyelet

terminal of the ground lead or the ground screw/bolt. Check the voltage with the key switch in both the "START" and "RUN" positions. A minimum of **7.25 volts** must be present.

a. If correct voltage is not measured, connect black voltmeter lead directly to the negative (-) post of the battery and test voltage again in both key positions. If correct voltage is now indicated, check the ground circuit connections. If the ground screw/bolt or any other fasteners in the ground circuit are black (oxide-coated), replace them with zinc plated (silver colored) fasteners.

b. If correct voltage is still not indicated, check the harness connector terminal for a good connection and crimp to the lead. Then trace the power source circuit back through the harness, key switch, etc., looking for any poor connections, or faulty circuits.

2. Disconnect **all** of the SAM leads, isolating it from the engine. Test the SAM with tester 25 761 21-S, following the instructions following or use TT481-A provided with the tester. If the SAM tests bad, replace it.

3. Reattach the SAM leads, verifying a snug fit at the ignition module terminals. If any connections do not feel snug, disconnect the lead, lightly pinch the female terminal with a pliers, and recheck the fit.

4. Seal the base of the ignition module connections with GE/Novaguard G661 (Kohler Part No. 25 357 11-S) or Fel-Pro Lubri-Sel dielectric compound. The beads should overlap between the two connections† to form a solid bridge of compound. **Do not** put any compound inside the connectors.

† The 24 584 15-S ignition modules have a separator/barrier between the terminals. On these modules, seal the base of the terminal if any portion of it is exposed, but it is not necessary to have overlapping beads of sealant between the connections.

5. Test for spark (Test 2) to be sure the system is working, before you reinstall the blower housing. If there is still a spark problem on one side, replace that ignition module and recheck spark.

To Test –

NOTE: SAM **must** be at room temperature (to the touch) when tested. Disconnect ALL of the SAM leads, isolating it from the main wiring harness and the ignition module(s). Testing may be performed with the module mounted or loose. The figures show the part removed from the engine for clarity.

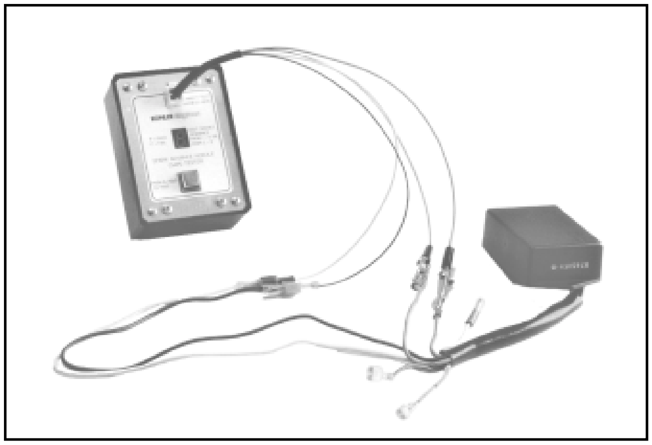


Figure 8-10.

1. Connect the tester to the SAM as follows:

Attach:

A. The **yellow** tester lead to the **long yellow** module lead.
B. The **brown** tester lead to the **long brown** module lead.
C. The **red** tester lead to the **red** module lead.
D. The green tester lead to the green module lead.

Caution: Do not allow the alligator clip leads to touch each other.

Figure 8-11.

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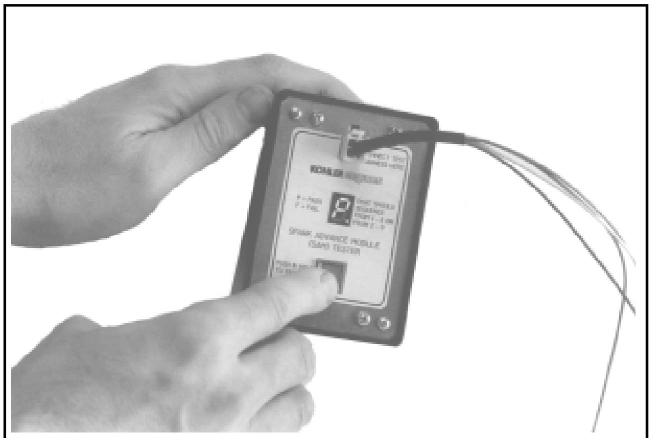

Figure 8-12.

2. Check the SAM part number, stamped on the side of the housing, and determine if you have an analog SAM (ASAM) or a digital SAM (DSAM). Follow sub-step a for an ASAM, and sub-step b for a DSAM. To help identify Service Bulletin 233 lists DSAM part numbers.

   a. **ASAM only:** Depress the tester button and hold it down. After approximately four seconds, a numerical sequence should be displayed, beginning with 1 or 2 and continuing to 8 or 9, followed by a letter "P" (pass) or "F" (fail). See Figures 8-11 and 8-12. **DO NOT** release the tester button until the test cycle completes and the display goes off*. If you get a "-" sign instead of the numerical sequence, and/or an "F" at the end of the cycle, the SAM is probably bad. Recheck all of the connections, check the condition of the tester battery** and repeat the test. If you get the "-" sign and/or "F" again in the retest, replace that SAM.

*IMPORTANT!

Allow 15-20 seconds for the tester to clear and reset itself between tests or if test is interrupted before completion of test cycle. Otherwise, a false reading may be displayed in the form of a "-" or a faint "8".

   b. **DSAM only:** DSAM firing points are different and testing can only determine if the DSAM is working not the actual firing points. Connect the tester in the same manner and start the test. If the numbers start advancing, the DSAM is working. If a dash appears, the DSAM is not working. Check all of the connections and retest. If it still is not working, replace the DSAM.

3. Disconnect the yellow and brown tester leads from the long module leads. Connect the brown tester lead to the short brown module lead. Connect the yellow tester lead to the short yellow (or pink) module lead. See Figure 8-13. Leave the red and green leads connected. Repeat step 2.

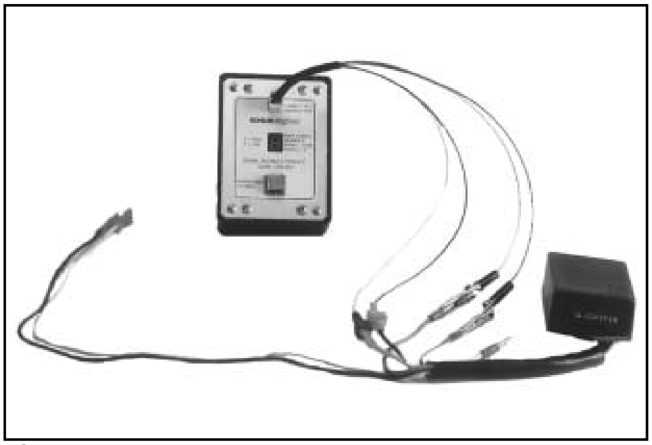

Figure 8-13.

**The tester is powered by a 9-volt battery. Most SAM's are designed to operate down to a minimum of 7.25 volts. If the tester battery drops below that level, incorrect test readings will result. The tester battery should be checked periodically by connecting a DC voltmeter between the red and green lead wires, with the tester connected to a SAM. Press and hold the test button for a full test cycle ("F" or "P" appears and then display shuts off), while monitoring the voltage reading on the voltmeter. If the voltage drops below 7.5 at any time during the cycle, the 9-volt tester battery must be replaced. Use an extended life (alkaline) battery.

To replace the battery, remove the outer set of screws on the faceplate and carefully lift the panel from the body. Unplug the connector and pull battery (with mounting tape) off the back of the tester. Attach the connector to the new battery and mount the battery to the case with double-backed tape. Reinstall the faceplate and secure with the four screws.

Battery Charging System

General

Most engines are equipped with a 15 or 20 amp regulated charging system. Some have a 25 amp regulated charging system. See Figure 8-14 for the 15/20/25 amp charging system diagram. Some engines utilize a 3 amp unregulated system with optional 70 watt lighting circuit. Refer to Figure 8-18.

NOTE: Observe the following guidelines to avoid damage to the electrical system and components:

- Make sure the battery polarity is correct. A negative (-) ground system is used.
- Disconnect the rectifier-regulator plug and/or the wiring harness plug before doing any electric welding on the equipment powered by the engine. Also, disconnect all other electrical accessories in common ground with the engine.
- Prevent the stator (AC) leads from touching or shorting while the engine is running. This could damage the stator.

15/20/25 amp Regulated Charging System

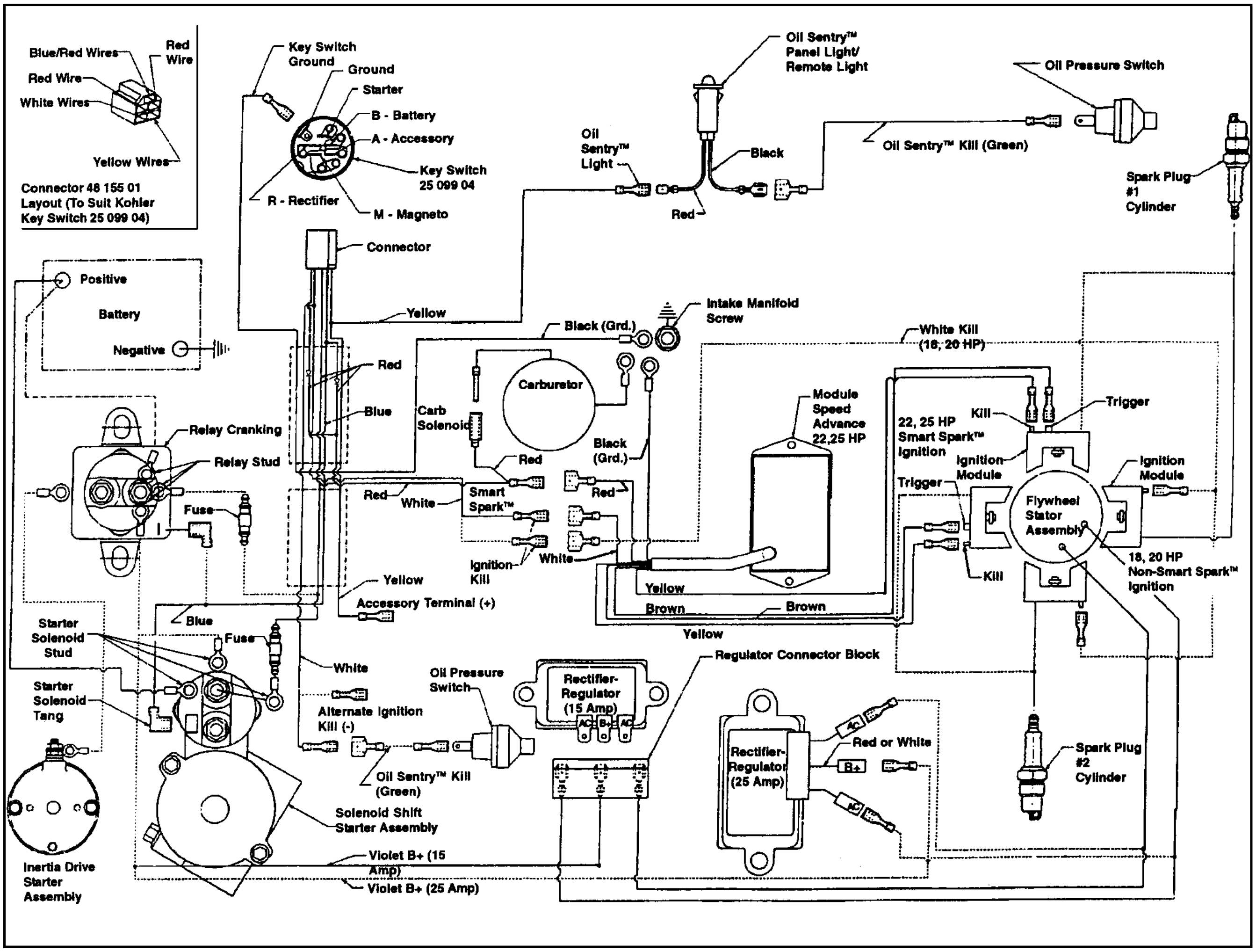

Figure 8-14. Wiring Diagram - 15/20/25 amp Regulated Battery Charging System.

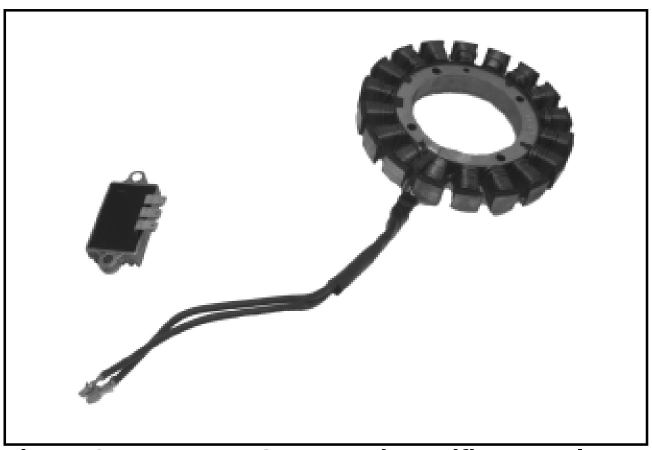

Figure 8-15. 15 amp Stator and Rectifier-Regulator.

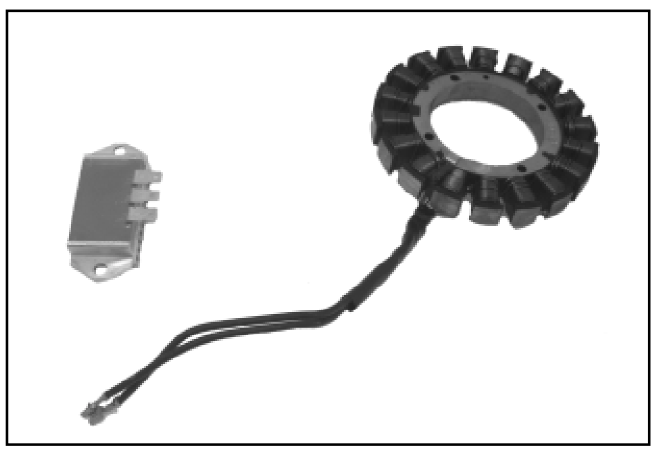

Figure 8-16. 20 amp Stator and Rectifier-Regulator.

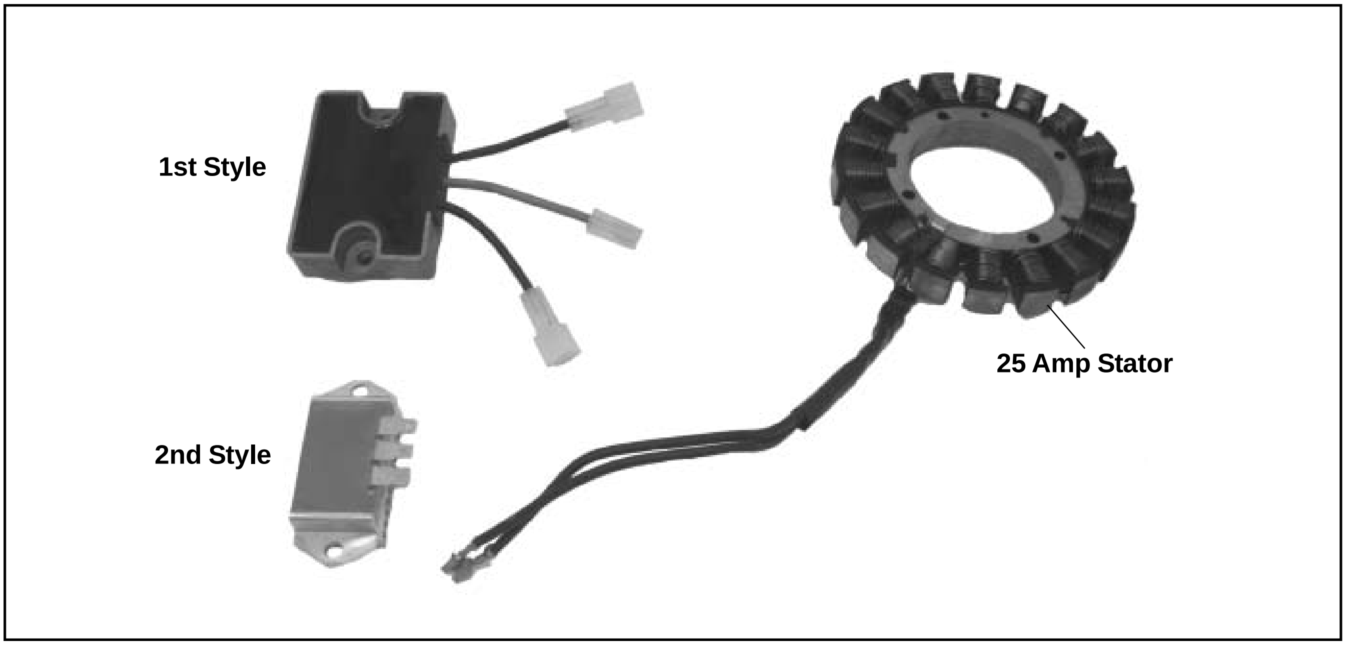

Figure 8-17. 25 amp Stator and Rectifier-Regulators.

3 amp Unregulated Charging System

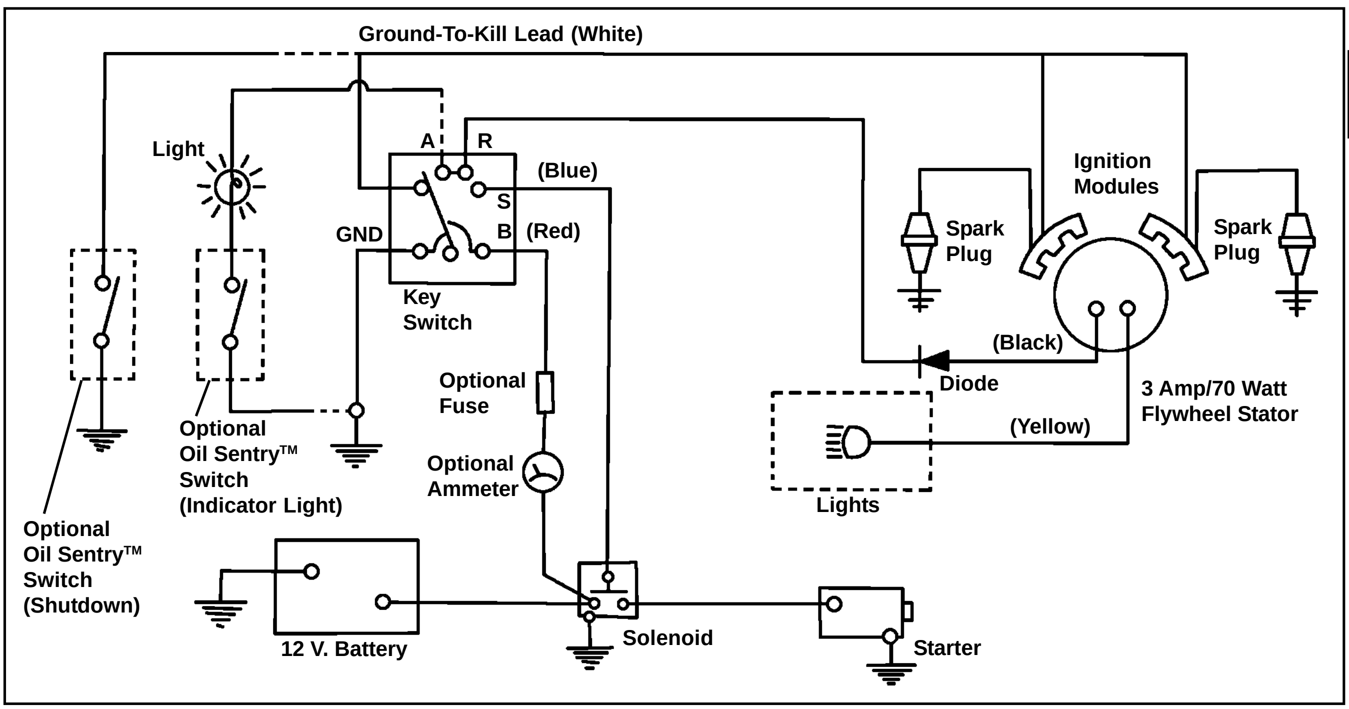

Figure 8-18. Wiring Diagram - 3 amp Unregulated Battery Charging System/70 Watt Lighting.

Section 8
Electrical System and Components

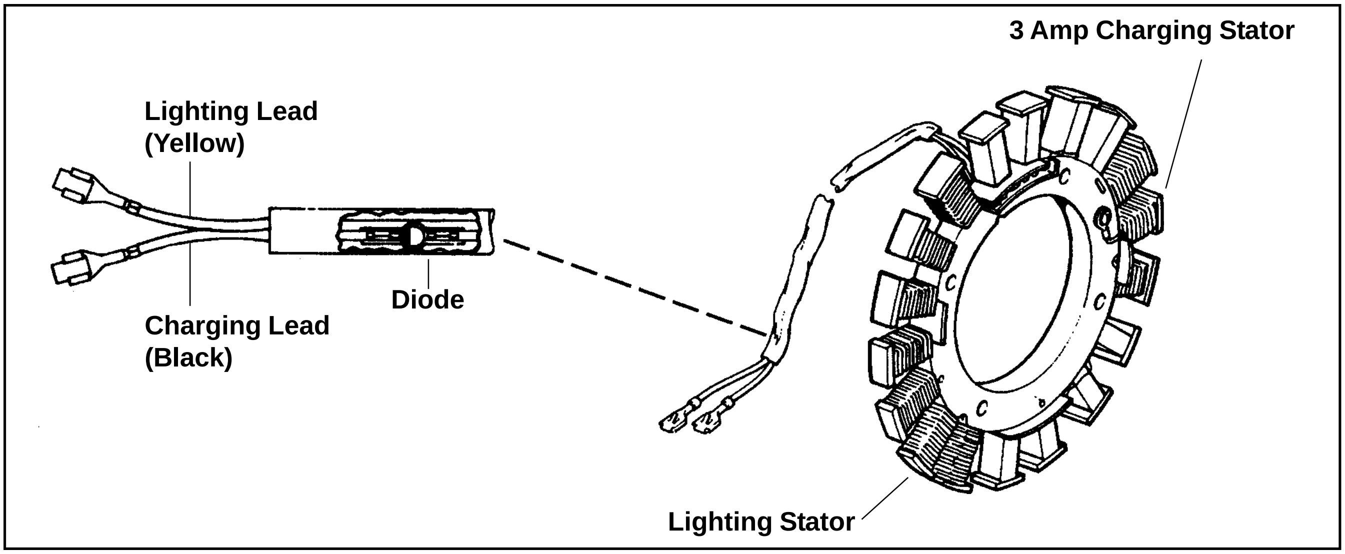

Figure 8-19. 3 amp/70 Watt Stator.

Stator

The stator is mounted on the crankcase behind the flywheel. Follow the procedures in Section 9 - “Disassembly” and Section 11 - “Reassembly” if stator replacement is necessary.

Rectifier-Regulator

The rectifier-regulator is mounted on the blower housing. See Figure 8-20. To replace it, disconnect the plug(s), remove the two mounting screws, and ground wire or metal grounding strap.

NOTE: When installing the rectifier-regulator, take note of the terminal markings and install the plug(s) accordingly.

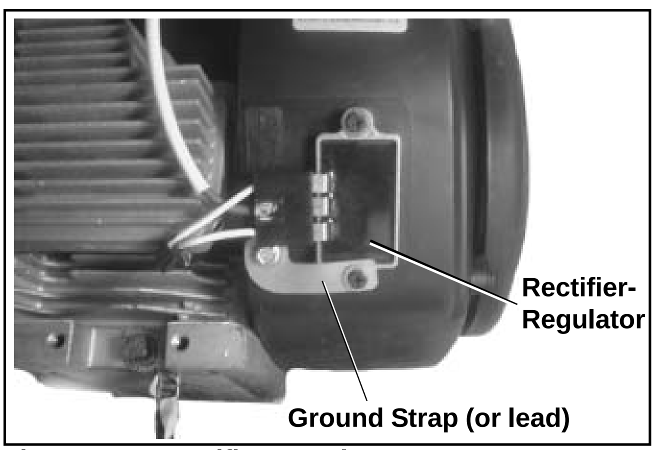

Figure 8-20. Rectifier-Regulator.

Testing of the rectifier-regulator may be performed as follows, using the Rectifier-Regulator Tester (SPX Part No. KO3221, formerly Kohler Part No. **25 761 20-S**).

To Test –

NOTE: Disconnect all electrical connections attached to the rectifier-regulator. Testing may be performed with the rectifier-regulator mounted or loose. The figures show the part removed from the engine for clarity. Repeat the applicable test procedure **two or three times** to determine the condition of the part.

15 Amp Rectifier-Regulators

1. Connect the tester ground lead (with spring clamp) to the body of the rectifier-regulator being tested.

2. Connect the tester red lead to the B+ terminal of the rectifier-regulator and the two black tester leads to the two AC terminals. See Figure 8-21.

Figure 8-21.

3. Plug the tester into a 110 volt AC outlet supply and turn on the power switch. See Figure 8-22. The ''POWER'' light should be illuminated and one of the four status lights may be on as well. This **does not** represent the condition of the part.

Figure 8-22.

4. Press the ''TEST'' button until a "click" is heard and then release. See Figure 8-23. Momentarily one of the four lights will illuminate, indicating the condition of the part.

Figure 8-23.

a. If the "OK" (green) light comes on and stays steady, the part is good and may be used.

b. If any other light is displayed,* the rectifier-regulator is faulty and should not be used.

*NOTE: A flashing "LOW" light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure.

20/25 Amp Rectifier-Regulators

1. Connect the single lead adapter in between the B+ (center) terminal of rectifier-regulator being tested and the squared single end of the tandem adapter lead. See Figure 8-24.

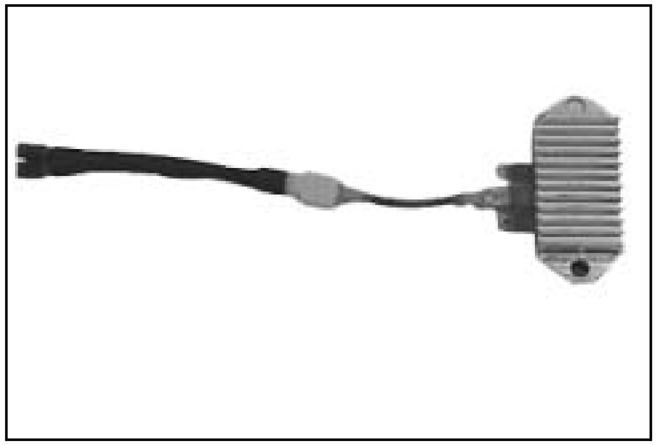

Figure 8-24.

2. Connect the tester ground lead (with spring clamp) to the body of the rectifier-regulator.

3. Connect the red lead and one of the black leads to the pair of terminals on the open end of the tandem adapter lead (connections are not location specific).

4. Connect the remaining black lead from the tester to one of the outer AC terminals on the rectifier-regulator. See Figure 8-25.

Figure 8-25.

5. Plug the tester into a 110 volt AC outlet and turn on the power switch. The ''POWER'' light should be illuminated and one of the four status lights may be on as well. See Figure 8-22. This **does not** represent the condition of the part.

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6. Press the ‘‘TEST’’ button until a ‘‘click’’ is heard and then release. See Figure 8-23. Momentarily one of the four lights will illuminate indicating the **partial condition** of the part.

   a. If the ‘‘OK’’ (green) light comes on, disconnect the tester black lead attached to one AC terminal and reconnect it to the other AC terminal. Repeat the test. If the ‘‘OK’’ (green) light comes on again, the part is good and may be used.

   b. If any other light is displayed* in either of the tests, the rectifier-regulator is faulty and should not be used.

*NOTE: A flashing ‘‘LOW’’ light can also occur as a result of an inadequate ground lead connection. Make certain the connection location is clean and the clamp is secure.

25 Amp Rectifier-Regulators (Original Style)

1. Connect the squared single end of the tandem lead adapter to the B+ (center/red) lead of rectifier-regulator being tested. See Figure 8-26.

Figure 8-26.

2. Connect the ground lead of tester (with spring clamp), to the housing of rectifier-regulator.

3. Connect the red lead and one of the black leads from the tester to the pair of terminals on opposite end of adapter lead (connections are not location specific.)

4. Connect the remaining black lead from tester to one of the black AC (outside) leads from rectifier-regulator. See Figure 8-27.

Figure 8-27.

5. Plug the tester into a 110 volt AC outlet/power supply and turn on the power switch. The ‘‘POWER’’ light should be illuminated and one of the four status lights may be on as well. See Figure 8-22. This **does not** represent the condition of the part.

6. Press the ‘‘TEST’’ button until a “click” is heard and then release. See Figure 8-23. Momentarily one of the four lights will relight indicating the **partial condition** of the part.

   a. If the “OK” (green) light comes on, disconnect the tester black lead attached to the AC lead, reconnect it to the opposite side AC lead, and repeat the test. If the “OK” light (green) again comes on, the part is good and may be used.

   b. If any other light is displayed* in either of the tests, the rectifier-regulator is faulty and should not be used.

*NOTE: A flashing “LOW” light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure.

4 Amp Unregulated Rectifiers

1. Connect the tester ground lead (with spring clamp), to the body of rectifier being tested.

2. Connect the red tester lead to the B+ (center) terminal of the rectifier and the two black tester leads to the two AC (outside) terminals. See Figure 8-28.

Figure 8-28.

3. Plug the tester into a 110 volt AC outlet and turn on the power switch. The ‘‘POWER’’ light should be illuminated and one of the four status lights may be on as well. See Figure 8-22. This **does not** represent the condition of the part.

4. Press the ‘‘TEST’’ button until a “click” is heard and then release. See Figure 8-23. Momentarily either the ‘‘HIGH’’, ‘‘LOW’’, or ‘‘SHORT’’ light will flash.

   a. If the “HIGH” light flashes on/off, the part is good and may be used.

   b. If any other light is displayed* the rectifier is faulty and should not be used.

*NOTE: A flashing “LOW” light can also occur as a result of an inadequate ground lead connection. Make certain connection location is clean and clamp is secure.

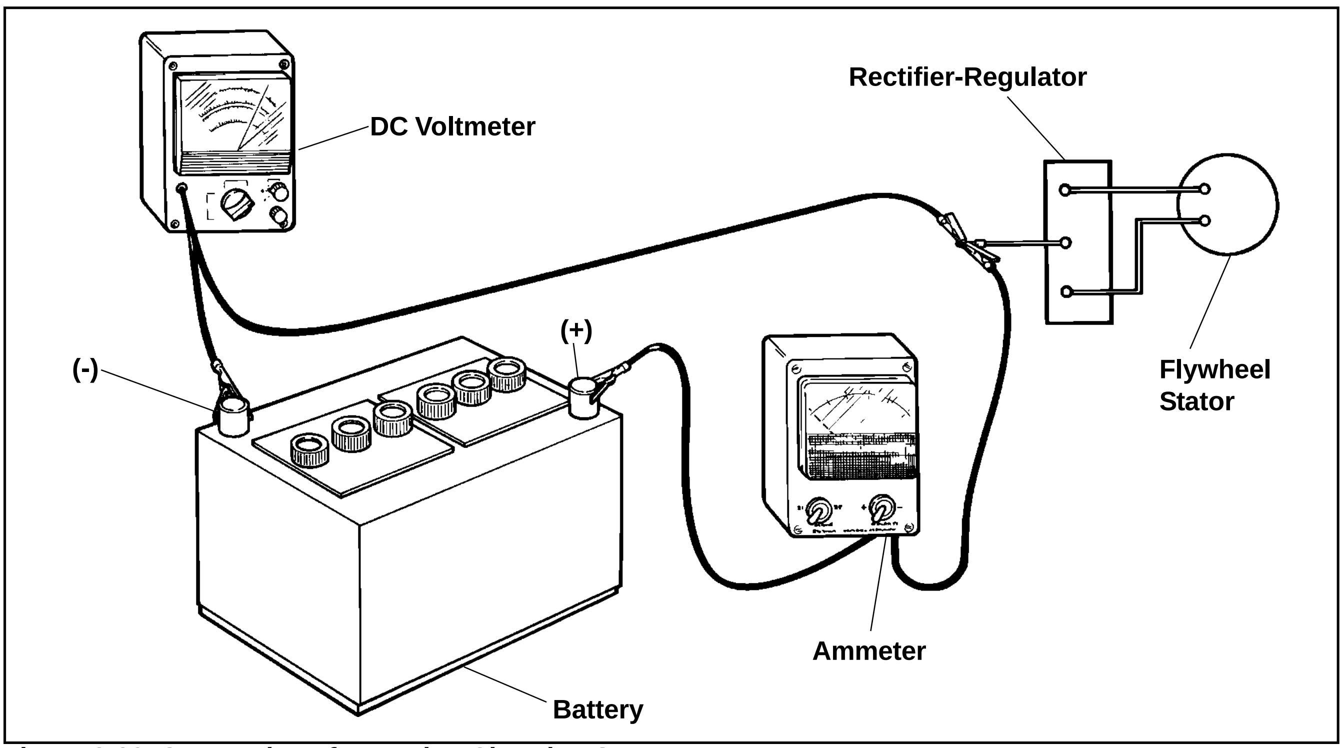

Figure 8-29. Connections for Testing Charging System.

Troubleshooting Guide

15/20/25 amp Battery Charging Systems
When problems occur in keeping the battery charged or the battery charges at too high a rate, the problem can usually be found somewhere in the charging system or with the battery.

NOTE: **Always zero ohmmeter on each scale before testing** to ensure accurate readings. Voltage tests should be made with the engine running at 3600 RPM - no load. **The battery must be good and fully charged.**

Problem	Test	Conclusion
No Charge to Battery	1. Trace B+ lead from rectifier-regulator to key switch, or other accessible connection. Disconnect it from switch or connection. Connect an ammeter from loose end of B+ lead to positive terminal of battery. Connect DC voltmeter from loose end of B+ lead to negative terminal of battery. With engine running at 3600 RPM, read voltage on voltmeter. If voltage is 13.8 volts or more, place a minimum load of 5 amps* on battery to reduce voltage. Observe ammeter. *NOTE: Turn on lights, if 60 watts or more. Or place a 2.5 ohm, 100 watt resistor across battery terminals.	1. If voltage is 13.8-14.7 and charge rate increases when load is applied, the charging system is OK and battery was fully charged. If voltage is less than 13.8 or charge rate does not increase when load is applied, test stator (Tests 2 and 3).
	2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is **28 volts or more,** stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator. If voltage is **less than 28 volts,** stator is probably faulty and should be replaced. Test stator further using an ohmmeter (Test 3).
	3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.	3a. If resistance is **0.064/0.2 ohms,** the stator is OK. If the resistance is **infinity ohms,** stator is open. Replace stator.
	3b. With the engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If the resistance is **infinity ohms** (no continuity), the stator is OK (not shorted to ground). If resistance (or continuity) **is measured,** the stator leads are shorted to ground. Replace stator.
Battery Continuously Charges at High Rate	1. Perform same test as step 1 above.	1. If the voltage is **14.7 volts or less** the charging system is OK. The battery is unable to hold a charge. Service battery or replace as necessary. If voltage is **more than 14.7 volts,** the rectifier-regulator is faulty. Replace rectifier-regulator.

Troubleshooting Guide

3 amp Battery Charging System with 70 Watt Lighting Stator

NOTE: Zero ohmmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3000 RPM - no load. **Battery must be good and fully charged.**

Problem	Test	Conclusion
No Charge to Battery	1. With engine running at 3000 RPM, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is more than 12.5 volts, charging system is OK. If voltage is 12.5 volts or less, the stator or diode are probably faulty. Test the stator and diode (Tests 2, 3 and 4).
	2. Disconnect the charging lead from battery. With engine running at 3000 RPM, measure voltage from charging lead to ground using a DC voltmeter.	2. If voltage is **28 volts or more**, stator winding is OK. If voltage is **less than 28 volts**, test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is low in both directions, the diode is shorted. Replace the diode. If resistance is high in both directions, the diode or stator winding is open. (Use Test 4.)
	4. Cut the sleeving on the charging lead to expose the diode connections. Measure the resistance from the stator side of diode to ground using an ohmmeter.	4. If resistance is approximately **1.07 ohms**, stator winding is OK. If resistance is **0 ohms**, stator winding is shorted. Replace stator. If resistance is **infinity ohms**, stator winding or lead is open. Replace stator.
No Lights	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead from the wiring harness. With engine running at 3000 RPM, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is **15 volts or more**, stator is OK. Check for loose connections or shorts in wiring harness. If voltage is **less than 15 volts**, test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approximately **0.4 ohms**, stator is OK. If resistance is **0 ohms**, stator is shorted. Replace stator. If resistance is **infinity ohms**, stator or lighting lead is open. Replace stator.

Electric Starting Motors

Some engines in this series use inertia drive starting motors while most use solenoid shift starters. The inertia drive types are covered first and the solenoid shift types following.

Starting Motor Precautions

NOTE: Do not crank the engine continuously for more than 10 seconds at a time. If the engine does not start, allow a 60 second cool-down period between starting attempts. Failure to follow these guidelines can burn out the starter motor.

NOTE: If the engine develops sufficient speed to disengage the starter but does not keep running (a false start), the engine rotation must be allowed to come to a complete stop before attempting to restart the engine. If the starter is engaged while the flywheel is rotating, the starter pinion and flywheel ring gear may clash, resulting in damage to the starter.

NOTE: If the starter does not crank the engine, shut off the starter immediately. Do not make further attempts to start the engine until the condition is corrected.

NOTE: Do not drop the starter or strike the starter frame. Doing so can damage the starter.

Starter Removal and Installation

Refer to the “Disassembly” and “Reassembly” Sections for starter removal and installation procedures.

Inertia Drive Electric Starters

This subsection covers the operation, troubleshooting, and repair of the inertia drive, permanent magnet electric starters.

Troubleshooting Guide – Starting Difficulties

Problem	Possible Fault	Correction
Starter Does Not Energize	**Battery**	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary.
	Wiring	1. Clean corroded connections and tighten loose connections. 2. Replace wires in poor condition and with frayed or broken insulation.
	Starter Switch or Solenoid	1. By-pass the switch or solenoid with a jumper wire. If starter cranks normally, replace the faulty components.
Starter Energizes but Turns Slowly	**Battery**	1. Check the specific gravity of battery. If low, recharge or replace battery as necessary.
	Brushes	1. Check for excessively dirty or worn brushes and commutator. Clean using a coarse cloth (not emery cloth). 2. Replace brushes if excessively or unevenly worn.
	Transmission or Engine	1. Make sure the clutch or transmission is disengaged or placed in neutral. This is especially important on equipment with hydrostatic drive. The transmission must be exactly in neutral to prevent resistance which could keep the engine from starting. 2. Check for seized engine components such as the bearings, connecting rod, and piston.

Operation - Inertia Drive Starters

When power is applied to the starter, the armature rotates. As the armature rotates, the drive pinion moves out on the splined drive shaft and into mesh with the flywheel ring gear. When the pinion reaches the end of the drive shaft, it rotates the flywheel and "cranks" the engine.

When the engine starts, the flywheel rotates faster than the starter armature and drive pinion. This moves the drive pinion out of mesh with the ring gear and into the retracted position. When power is removed from the starter, the armature stops rotating and the drive pinion is held in the retracted position by the anti-drift spring.

Starter Drive Service

Every **500 hours** of operation (or annually, whichever occurs first), clean and lubricate the splines on the starter drive shaft. If the drive pinion is worn, or has chipped or broken teeth, it must be replaced. See Figure 8-30.

It is not necessary to completely disassemble the starter to service the drive components.

Style "A" Drive Service

1. Remove the starter from the engine and remove the dust cover.
2. Hold the drive pinion in a vice with soft jaws when removing or installing the stop nut. The armature will rotate with the nut until the drive pinion stops against internal spacers.

NOTE: Do not overtighten the vise as this can distort the drive pinion.

3. Remove the stop nut, stop gear spacer, anti-drift spring, dust cover spacer, and drive pinion.
4. Clean the splines on drive shaft thoroughly with solvent. Dry the splines thoroughly.
5. Apply a small amount of Kohler electric starter drive lubricant, Part No. **52 357 01-S**, to the splines. The use of other lubricants may cause the drive pinion to stick or bind.
6. Apply a small amount of Loctite® No. 271 to the stop nut threads.
7. Install the drive pinion, dust cover spacer, anti-drift spring, stop gear spacer, and stop nut. Torque the stop nut to **17.0-19.2 N·m (150-170 in. lb.)**. Reinstall the dust cover.

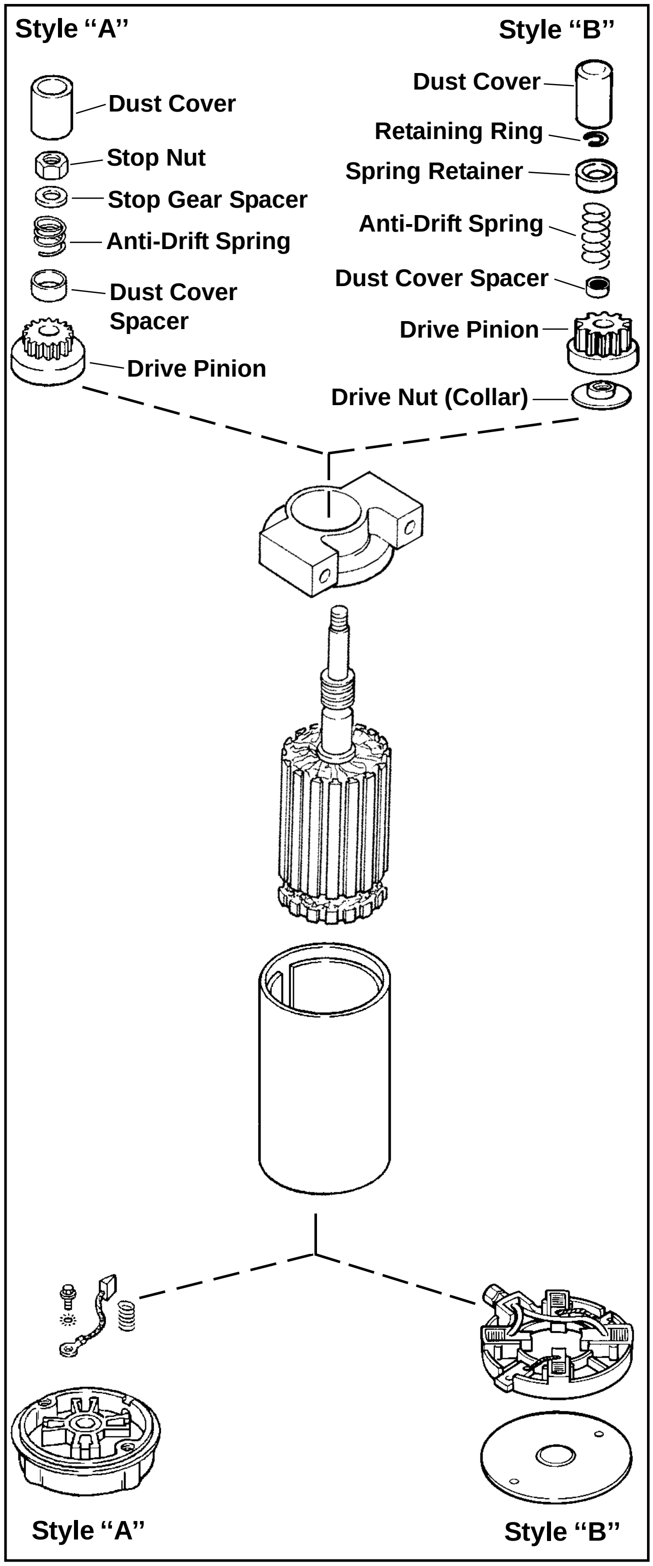

Figure 8-30. Inertia Drive Electric Starter.

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Style "B" Drive Service

1. The rubber dust cover has a molded lip on the inside that snaps into a groove in the dust cover spacer (see Figure 8-31). Turn the drive pinion clockwise until it reaches the fully extended position. While holding it in the extended position, grasp the tip of the dust cover with a pliers or vise grip and pull it free from the spacer.

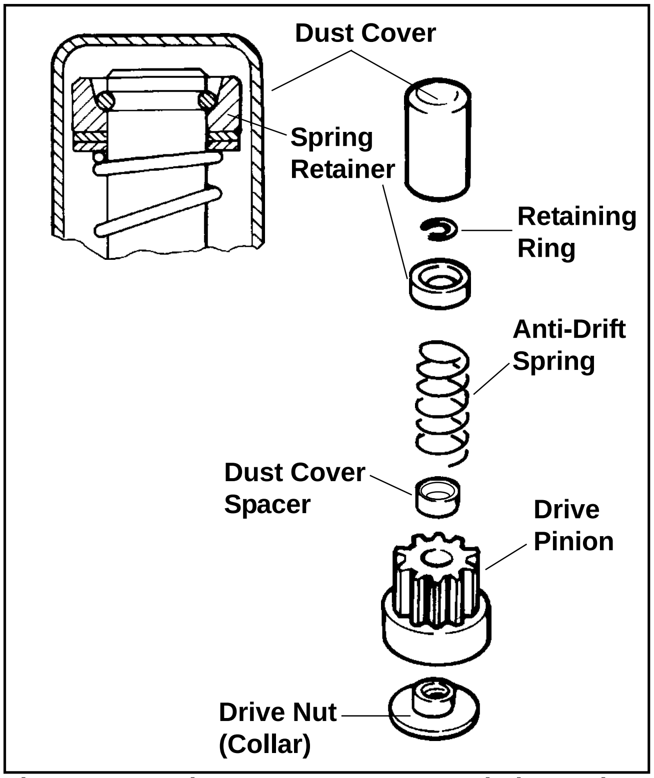

Figure 8-31. Drive Components, "Bonded" Inertia Drive Starter.

2. Disassemble the snap ring removal tool, SPX Part No. KO1049 (formerly Kohler Part No. **25 761 18-S**).

3. Again referring to Figure 8-31, grasp the spring retainer and push it toward the starter, compressing the anti-drift spring and exposing the retaining ring.

4. Holding the spring retainer in the retracted position, assemble the inner halves of the removal tool around the armature shaft with the retaining ring in the inner groove (see Figure 8-32). Slide the collar over the inner halves to hold them in position.

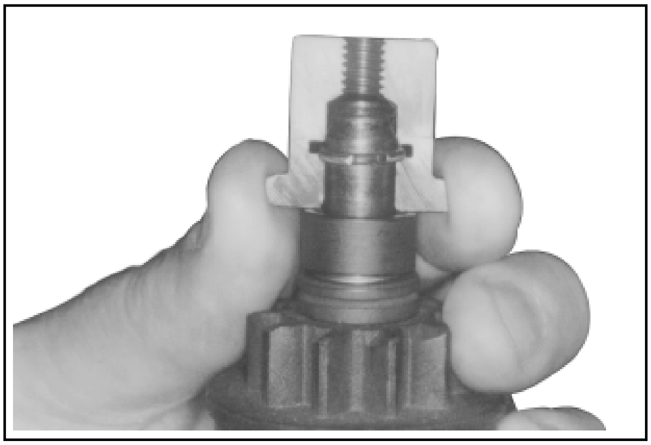

Figure 8-32. Assembling Inner Half of Tool Around Armature Shaft and Retaining Ring.

5. Thread the center screw into the removal tool until you feel resistance. Use a wrench (1-1/8" or adjustable) to hold the base of the removal tool. Use another wrench or socket (1/2" or 13 mm) to turn the center screw clockwise (see Figure 8-33). The resistance against the center screw will tell you when the retaining ring has popped out of the groove in the armature shaft.

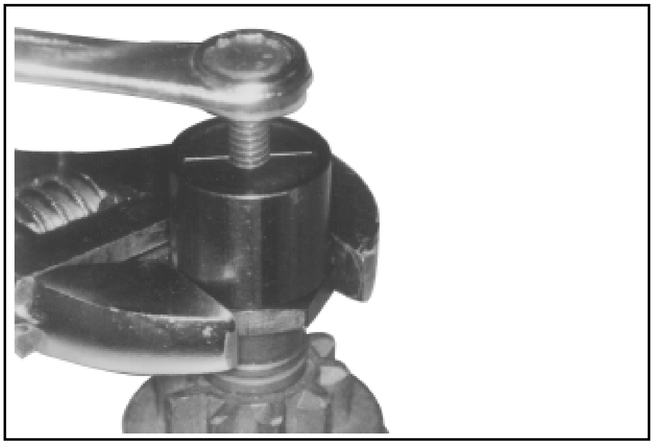

Figure 8-33. Holding Tool and Turning Center Screw (Clockwise) to Remove Retaining Ring.

6. Remove the drive components from the armature shaft, paying attention to the sequence. If the splines are dirty, clean them with solvent.

7. The splines should have a light film of lubricant. Relubricate as necessary with Kohler bendix starter lubricant (Part No. **52 357 01-S**). Reinstall or replace the drive components, assembling them in the reverse order they were removed.

Retaining Ring Installation
1. Position the retaining ring in the groove in one of the inner halves. Assemble the other half over the top and slide on the outer collar.

2. Be certain the drive components are installed in correct sequence onto the armature shaft.

3. Slip the tool over the end of the armature shaft, so the retaining ring inside is resting on the end of the shaft. Hold the tool with one hand, exerting slight pressure toward the starter. Tap the top of the tool with a hammer until you feel the retaining ring snap into the groove. Disassemble and remove the tool.

4. Squeeze the retaining ring with a pliers to compress it into the groove.

5. Assemble the inner halves with the larger cavity around the spring retainer (see Figure 8-34). Slide the collar over them and thread the center screw in until resistance is felt.

Figure 8-34. Assembling Larger Inner Half Around Spring Retainer.

6. Hold the base of the tool with a 1-1/8" wrench and turn the center screw clockwise with a 1/2" or 13 mm wrench to draw the spring retainer up around the retaining ring. Stop turning when resistance increases. Disassemble and remove tool.

7. Reinstall the dust cover.

Starter Disassembly
1. Remove the drive components following the instructions for servicing the drive.

2. Locate the small raised line on the edge of the drive end cap. On starters with Style "A" commutator end caps, it will be aligned with a premarked line on the starter frame. The frame is not premarked on starters with Style "B" end caps. Place a piece of masking tape on the frame and mark a line on the tape in line with the raised line on the end cap. See Figure 8-37.

3. Remove the thru bolts.

4. Remove the commutator end cap with brushes and brush springs (Style "A"). Style "B" end caps remove as a separate piece with the brushes and carrier remaining in the frame.

5. Remove the drive end cap.

6. Remove the armature and thrust washer (if so equipped) from inside the starter frame.

7. Remove the brush/carrier assembly from the frame (Style "B" starters).

Style "A" End Cap Brush Replacement
1. Remove the brush springs from the pockets in the brush holder. See Figure 8-35.

2. Remove the self-tapping screws, negative (-) brushes, and plastic brush holder.

3. Remove the hex. flange nut and fiber washer from the stud terminal.

   Remove the stud terminal with the positive (+) brushes and plastic insulating bushing from the end cap.

4. Install the insulating bushing on the stud terminal, of the new positive (+) brushes. Install the stud terminal into the commutator end cap. Secure the stud with the fiber washer and hex. flange screw.

5. Install the brush holder, new negative (-) brushes, and self-tapping screws.

6. Install the brush springs and brushes into the pockets in brush holder. Make sure the chamfered sides of the brushes are away from the brush springs.

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NOTE: Use a brush holder tool to keep the brushes in the pockets. A brush holder tool can easily be made from thin sheet metal. See Figure 8-36.

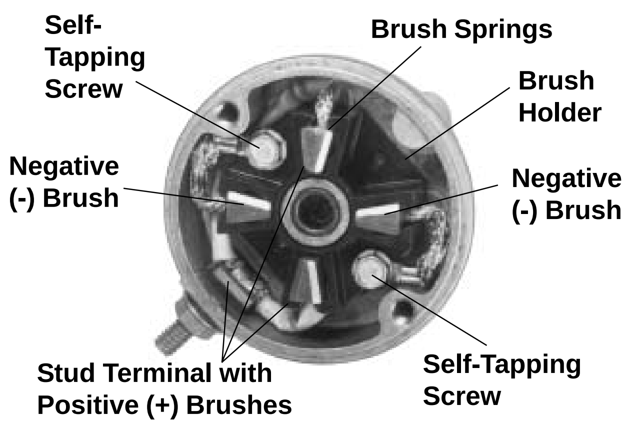

Figure 8-35. Style "A" Commutator End Cap with Brushes.

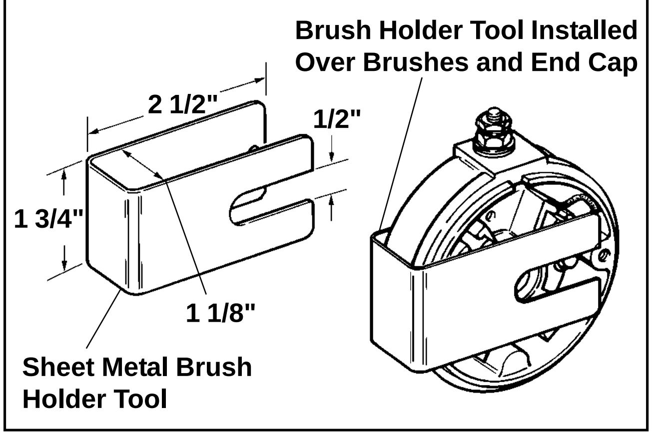

Figure 8-36. Brush Holder Tool (Style "A" End Cap).

Style "B" End Cap Brush Replacement
Starters with Style "B" end caps have the brushes in a plastic carrier housing, separate from the end cap. Replacement brushes come preassembled in the carrier housing, retained with two carton staples.

Commutator Service
Clean the commutator with a coarse, lint free cloth. Do not use emery cloth.

If the commutator is badly worn or grooved, turn it down on a lathe or replace the armature.

Starter Reassembly
1. Place the thrust washer (if so equipped) over the drive shaft of the armature.
2. Insert the armature into the starter frame. Make sure the magnets are closer to the drive shaft end of armature. The magnets will hold the armature inside the frame.
3. Install the drive end cap over the drive shaft. Make sure the match marks on the end cap and starter frame are aligned. See Figure 8-37.

Figure 8-37. Starter Assembly Match Marks.

For Style "A" Commutator End Caps:
4. Install the brush holder tool to keep the brushes in the pockets of the commutator end cap.
5. Align the match marks on the commutator end cap and the starter frame. Hold the drive end and the commutator end caps firmly to the starter frame. Remove the brush holder tool.

For Style "B" Commutator End Caps:
4. If the brush assembly is not being replaced, position the brushes in their pockets in the carrier. Move them to the retracted position, and install carton staples to retain them. See Figure 8-38.
5. Align the terminal stud block with the notch in the starter frame and slide the brush/carrier assembly into the frame. The commutator will push the carton staples out as the brush assembly is installed. Position the end cap over the brush assembly, so the holes for the thru bolts are aligned with those in the brush carrier.

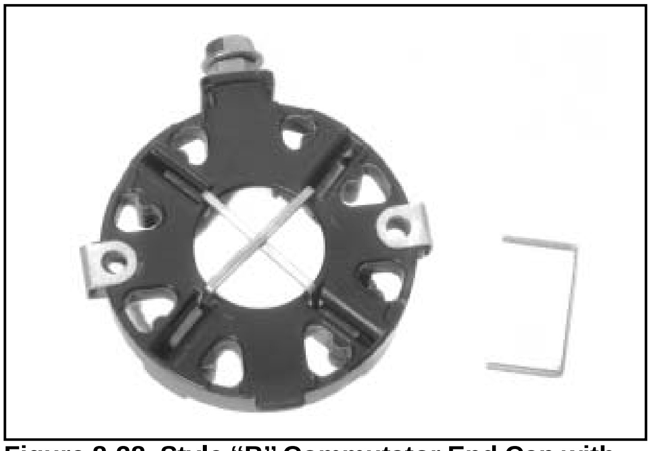

Figure 8-38. Style "B" Commutator End Cap with Brushes.

6. Install the thru bolts and tighten securely.

7. Lubricate the drive shaft with Kohler bendix starter drive lubricant (Part No. **52 357 01-S**). Install the drive components following the instructions for servicing the starter drive.

Solenoid Shift Electric Starters

The following subsection covers the solenoid shift electric starters. Much of the information in the proceeding subsection relates to this type starter also, so it is not repeated here. A Nippondenso or Delco-Remy solenoid shift starter may be used. The Nippondenso starter is covered first, and the Delco-Remy starter servicing follows.

Operation – Solenoid Shift Starter

When power is applied to the starter the electric solenoid moves the drive pinion out onto the drive shaft and into mesh with the flywheel ring gear. When the pinion reaches the end of the drive shaft it rotates the flywheel and cranks the engine.

When the engine starts and the start switch is released the starter solenoid is deactivated, the drive lever moves back, and the drive pinion moves out of mesh with the ring gear into the retracted position.

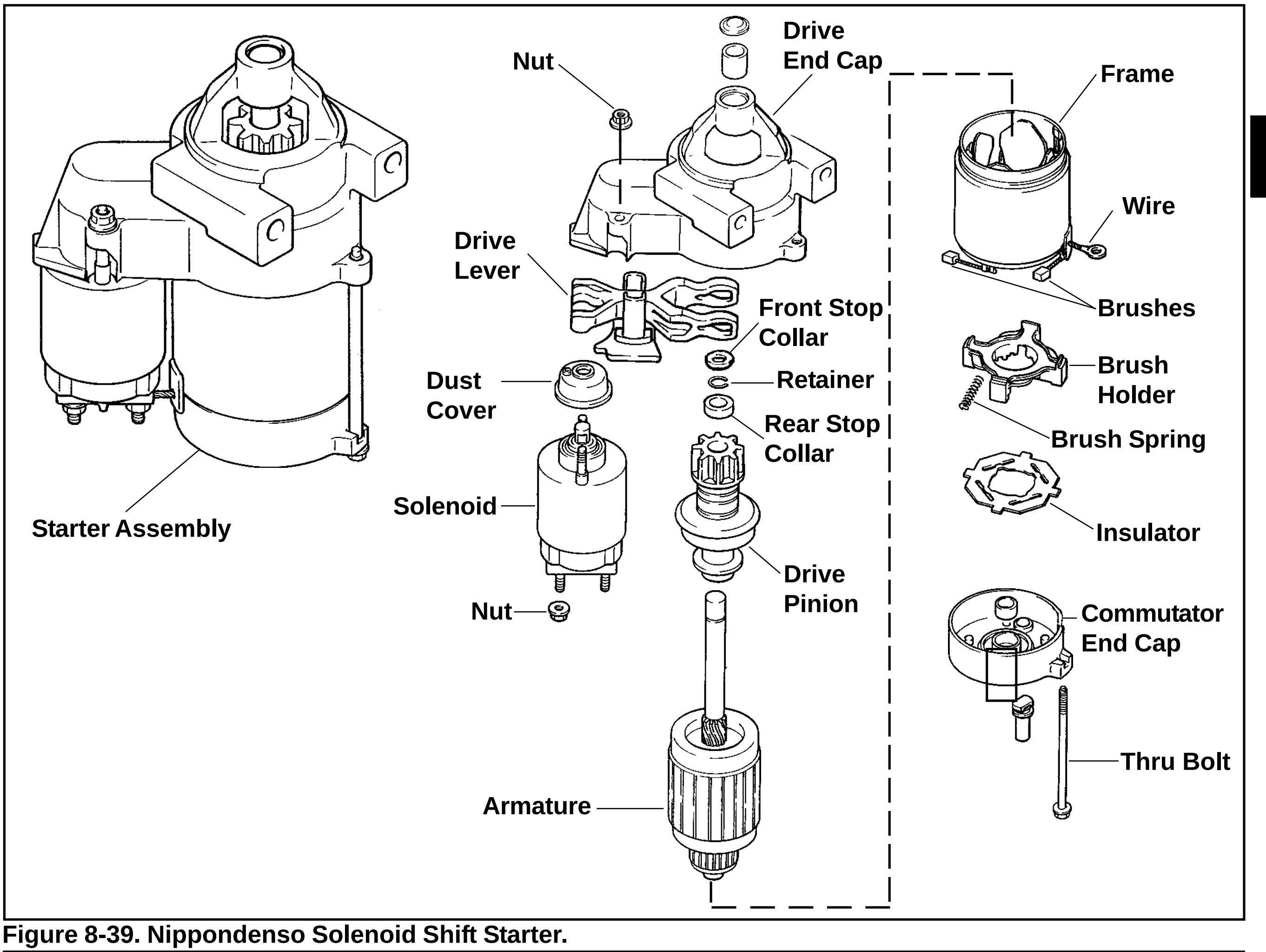

Figure 8-39. Nippondenso Solenoid Shift Starter.

Starter Disassembly

1. Disconnect the lead wire from the solenoid.

2. Remove the hex. nuts securing the solenoid, and remove the solenoid from the starter assembly.

3. Remove the two thru bolts.

4. Remove the commutator end cap.

5. Remove the insulator and the brush springs from the brush spring holder.

6. Remove the armature from the frame.

7. Remove the drive lever and the armature from the drive end cap.

   NOTE: When removing the lever and the armature be careful not to lose the thrust washer.

8. The stop collar consists of two similar pieces held in place by being snapped over a retainer. The retainer is held in place by a groove in the armature shaft. To remove the stop collar the two pieces must be pried off the retainer.

9. When the stop collars are removed the retainer can be removed from the armature shaft. Do not reuse the retainer.

Brush Replacement

The brushes in the starter are part of the starter frame. Brush kit, Kohler Part No. **52 221 01-S**, contains four replacement brushes and springs. If replacement is necessary, all four brushes should be replaced.

1. Remove the brushes from the brush holder, and remove the brush holder from the frame.

2. Cut the brush lead wire at the edge of the post with a pair of nippers.

3. File off any burrs on the post.

4. The replacement brushes have a solid portion on them which should be crimped on the post.

5. Solder the crimped portion to the post.

6. Replace the brush holder in the frame and place the brushes in the brush holder. Reinstall the springs.

Starter Service

Every **500 hours** of operation (or annually, whichever comes first), solenoid shift starters must be disassembled, cleaned and relubricated. Apply starter lubricant (Kohler Part No. **52 357 02-S**) to the lever and shaft. Failure to do so could result in an accumulation of dirt or debris that might prevent the engine from starting and could cause damage to the starter or the flywheel. Service may be necessary more frequently under dusty or dirty conditions.

Starter Reassembly

1. Insert the rear stop collar on the armature shaft.

2. Place the retainer in the groove on the armature shaft.

   NOTE: Always use a new retainer. Tighten the retainer in the groove to secure.

3. Fit the front stop collar over the shaft and bring the front and the rear stop collars together over the retainer. Using two pairs of pliers apply even force to the two collars until they snap over the retainer and nest into one another.

4. Reassemble the remaining components of the starter in reverse order from disassembly.

Delco-Remy Starters

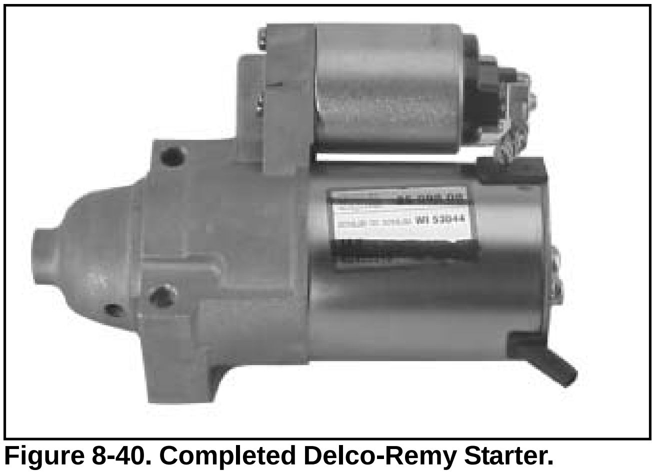

Figure 8-40. Completed Delco-Remy Starter.

Starter Disassembly

1. Remove the hex. nut and disconnect the positive (+) brush lead/bracket from the solenoid terminal.

2. Remove the three screws securing the solenoid to the starter. See Figure 8-41.

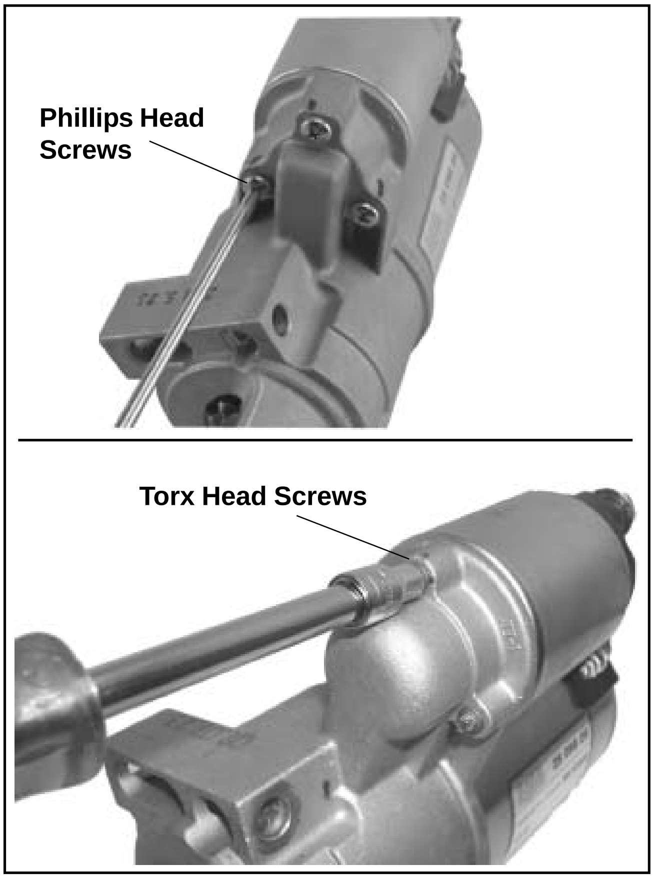

Figure 8-41. Removing Solenoid Screws.

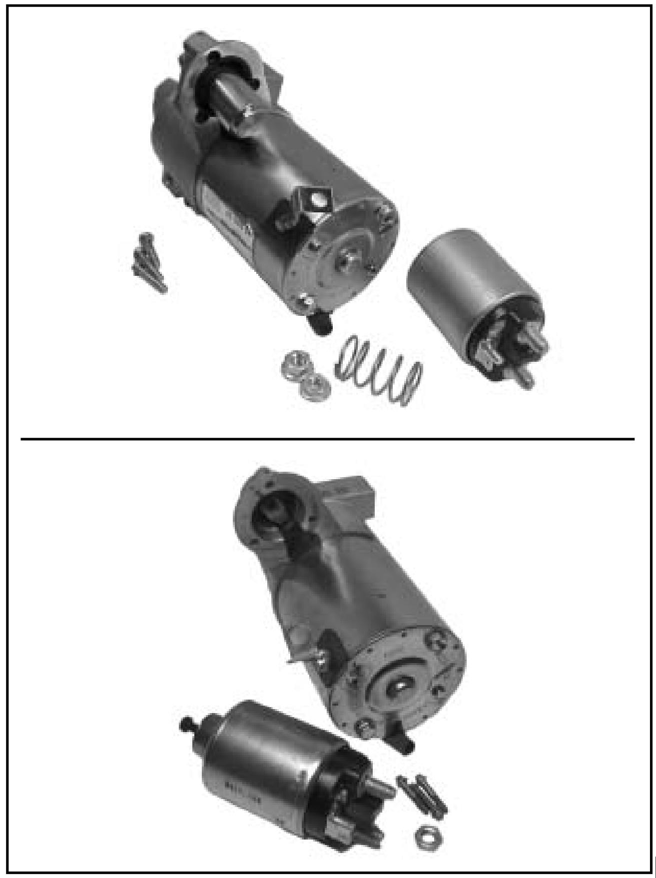

Figure 8-42. Solenoid Removed from Starter.

3. If the solenoid was mounted with Phillips head screws, separate the solenoid and plunger spring from the drive end cap. If the solenoid was mounted with external Torx head screws, the plunger is part of the solenoid, unhook the plunger pin from the drive lever. Remove the gasket from the recess in the housing. See Figures 8-42 and 8-43.

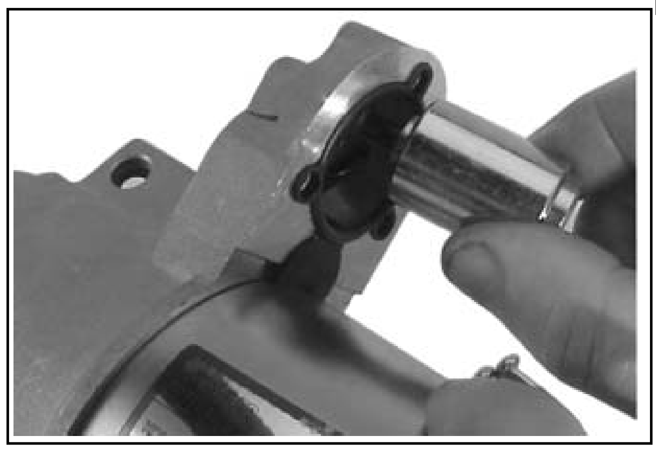

Figure 8-43. Removing Plunger.

4. Remove the two thru (larger) bolts. See Figure 8-44.

Figure 8-44. Removing Thru Bolts.

5. Remove the commutator end plate assembly, containing the brush holder, brushes, springs, and locking caps. Remove the thrust washer from inside the commutator end. See Figure 8-45.

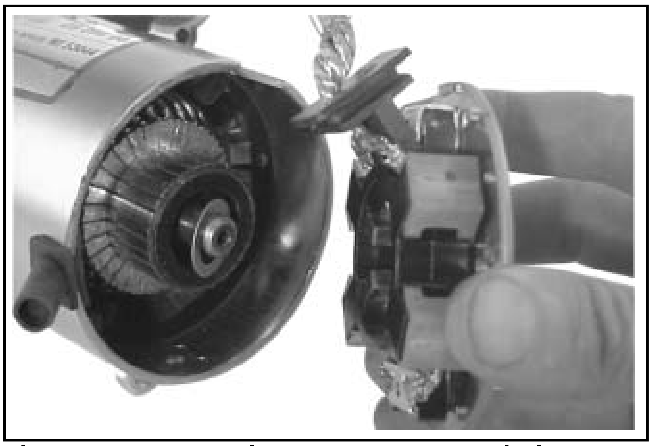

Figure 8-45. Removing Commutator End Plate Assembly.

6. Remove the frame from the armature and drive end cap. See Figure 8-46.

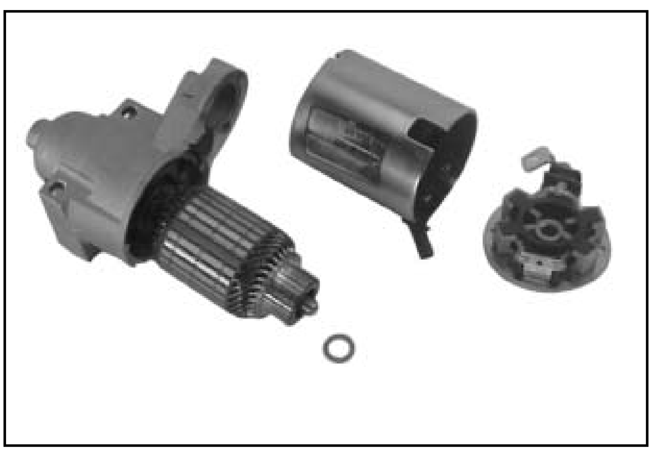

Figure 8-46. Starter Frame Removed.

7. Remove the drive lever pivot bushing and backing plate from the end cap. See Figure 8-47.

Figure 8-47.

8. Take out the drive lever and pull the armature out of the drive end cap. See Figure 8-48.

9. Remove the thrust washer from the armature shaft. See Figure 8-48.

Figure 8-48. Armature and Lever Removed.

10. Push the stop collar down to expose the retaining ring. See Figure 8-49.

Figure 8-49. Retaining Ring Detail.

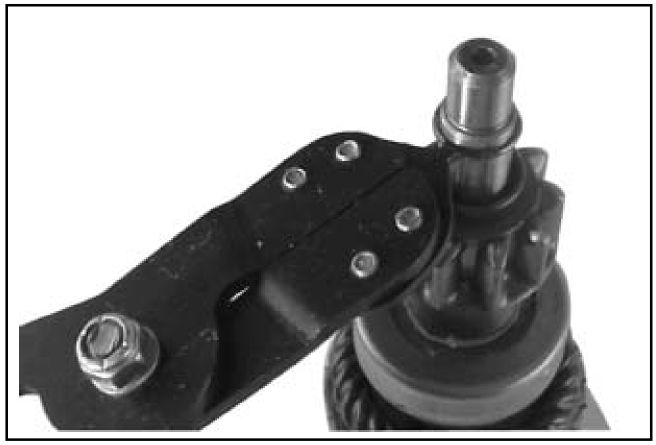

Figure 8-50. Removing Retaining Ring.

11. Remove the retainer from the armature shaft. Save the stop collar.

NOTE: Do not reuse the old retainer.

12. Remove the drive pinion assembly from the armature.

13. Clean the parts as required.

NOTE: **Do not** soak the armature or use solvent when cleaning. Wipe clean using a soft cloth, or use compressed air.

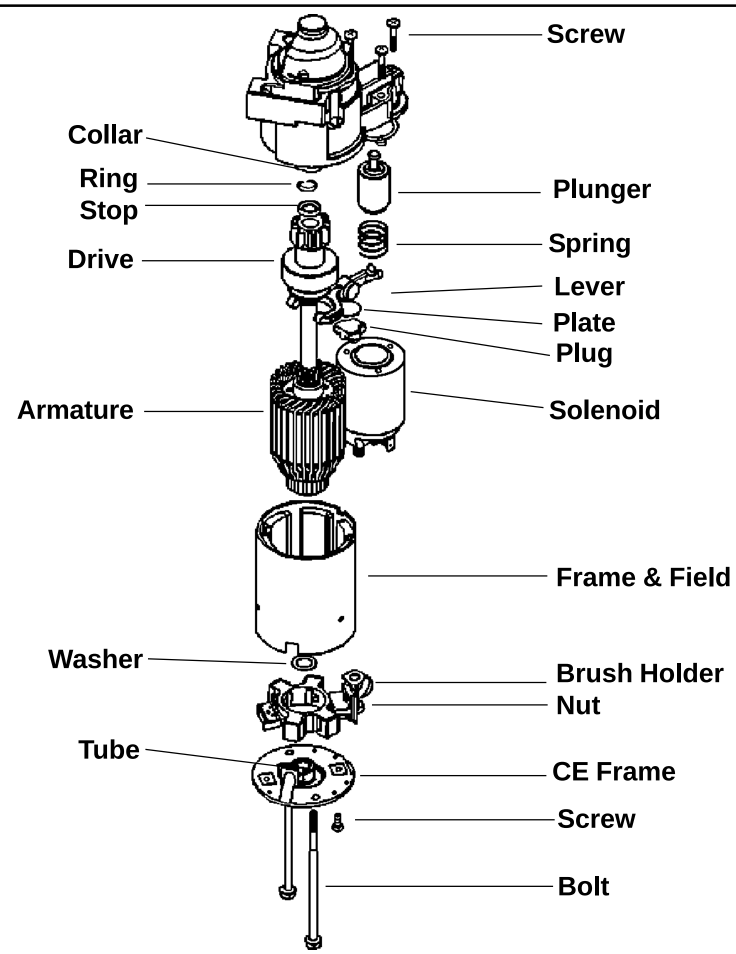

Figure 8-51. Delco-Remy Starter.

Inspection

Drive Pinion
Check and inspect the following areas:

a. The pinion teeth for abnormal wear or damage.

b. The surface between the pinion and the clutch mechanism for nicks, or irregularities which could cause seal damage.

c. Check the drive clutch by holding the clutch housing and rotating the pinion. The pinion should rotate in one direction only.

Brushes and Springs
Inspect both the springs and brushes for wear, fatigue, or damage. Measure the length of each brush. The minimum length for each brush is **7.6 mm (0.300 in.)**. See Figure 8-52. Replace the brushes if they are worn undersize, or their condition is questionable.

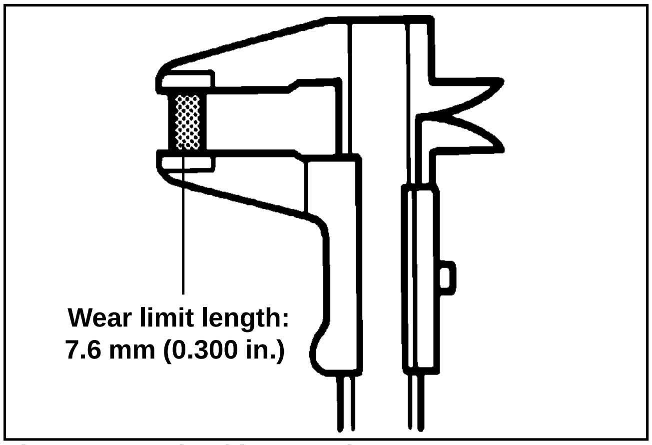

Figure 8-52. Checking Brushes.

Armature

1. Clean and inspect the commutator (outer surface). The mica insulation must be lower than the commutator bars (undercut) to ensure proper operation of the commutator. See Figure 8-53.

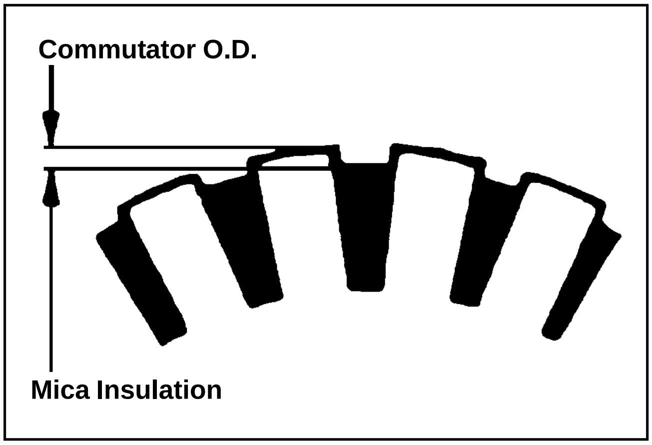

Figure 8-53. Commutator Mica Inspection.

2. Use an ohmmeter set to the Rx1 scale. Touch the probes between two different segments of the commutator, and check for continuity. See Figure 8-54. Test all the segments. Continuity must exist between all or the armature is bad.

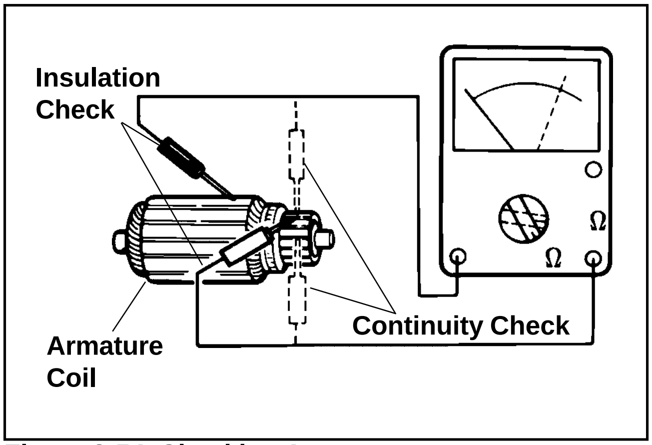

Figure 8-54. Checking Armature.

3. Check for continuity between the armature coil segments and the commutator segments. See Figure 8-54. There should be no continuity. If continuity exists between any two, the armature is bad.

4. Check the armature windings/insulation for shorting.

Shift Fork

Check that the shift fork is complete, and the pivot and contact areas are not excessively worn, cracked or broken.

Brush Replacement

The brushes and springs are serviced as a set (4). Use Brush and Spring Kit, Kohler Part No. **25 221 01-S**, if replacement is necessary.

1. Perform steps 1-5 in “Starter Disassembly.”

2. Remove the two screws securing the brush holder assembly to the end cap (plate). Note the orientation for reassembly later. See Figure 8-55. Discard the old brush holder assembly.

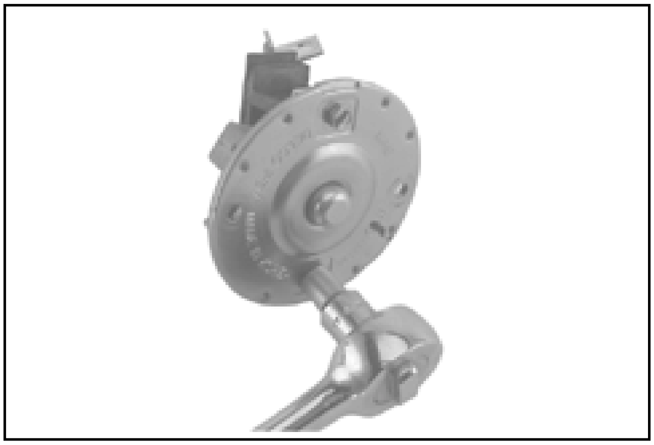

Figure 8-55. Removing Brush Holder.

3. Clean the component parts as required.

4. The new brushes and springs come preassembled in a brush holder with a protective sleeve that will also serve as an installation tool. See Figure 8-56.

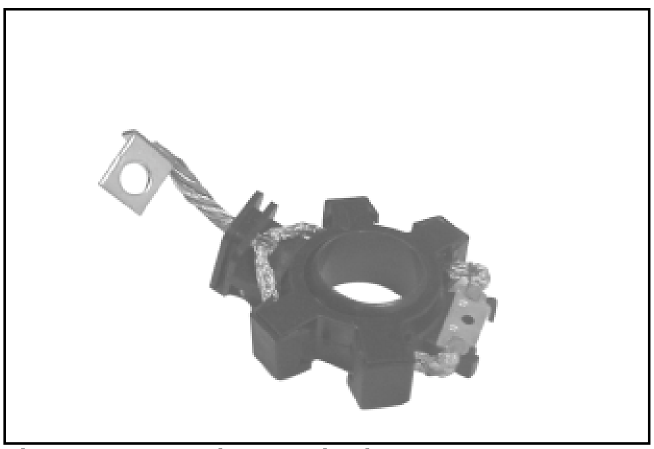

Figure 8-56. Service Brush Kit.

5. Perform Steps 10-13 in the “Starter Reassembly” sequence. Installation must be done after the armature, drive lever, and frame are installed, if the starter has been disassembled.

Starter Service

Clean the drive lever and armature shaft. Apply Kohler electric starter drive lubricant Part No. **52 357 02-S** (Versilube G322L or Mobil Temp SHC 32) to the lever and shaft. Clean and check the other starter parts for wear or damage as required.

Starter Reassembly

1. Apply drive lubricant (Kohler Part No. **52 357 02-S**) to the armature shaft splines. Install the drive pinion onto the armature shaft.

2. Install and assemble the stop collar/retainer assembly.

   a. Install the stop collar down onto the armature shaft with the counter bore (recess) up.

   b. Install a new retainer in the larger (rear) groove of the armature shaft. Squeeze with a pliers to compress it in the groove.

   c. Slide the stop collar up and lock it into place, so the recess surrounds the retainer in the groove. If necessary, rotate the pinion outward on the armature splines against the retainer to help seat the collar around the retainer.

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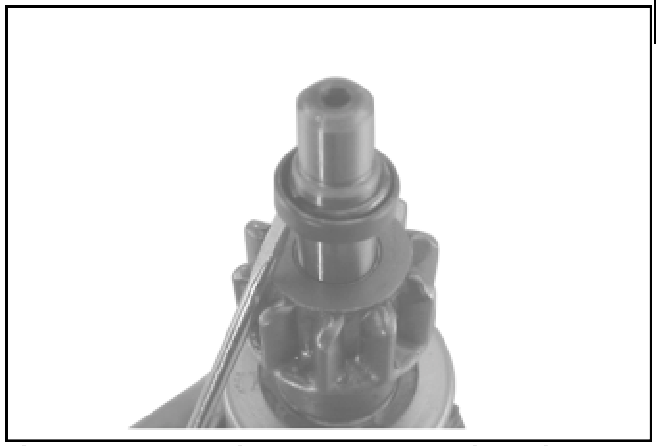

Figure 8-57. Installing Stop Collar and Retainer.

NOTE: Always use a new retainer. Do not reuse old retainers which have been removed.

3. Install the offset thrust (stop) washer so the smaller “offset” of the washer faces the retainer/ collar. See Figure 8-58.

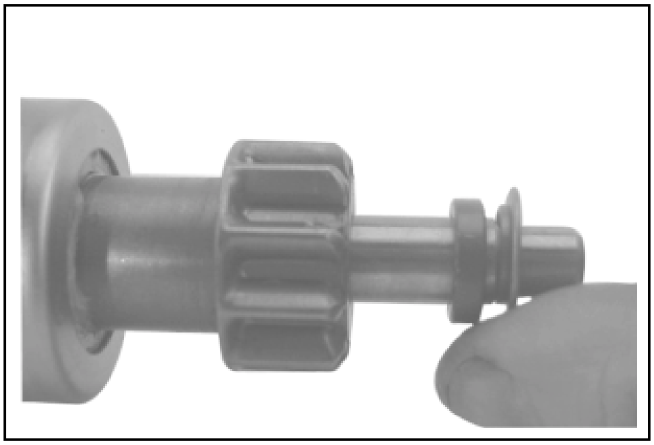

Figure 8-58. Installing Thrust Washer.

4. Apply a small amount of oil to the bearing in the drive end cap, and install the armature with the drive pinion.

5. Lubricate the fork end and center pivot of the drive lever with drive lubricant (Kohler Part No. **52 357 02-S**). Position the fork end into the space between the captured washer and the rear of the pinion.

6. Slide the armature into the drive end cap, and at the same time seat the drive lever into the housing.

NOTE: Correctly installed, the center pivot section of the drive lever will be flush or below the machined surface of the housing which receives the backup washer. See Figure 8-59.

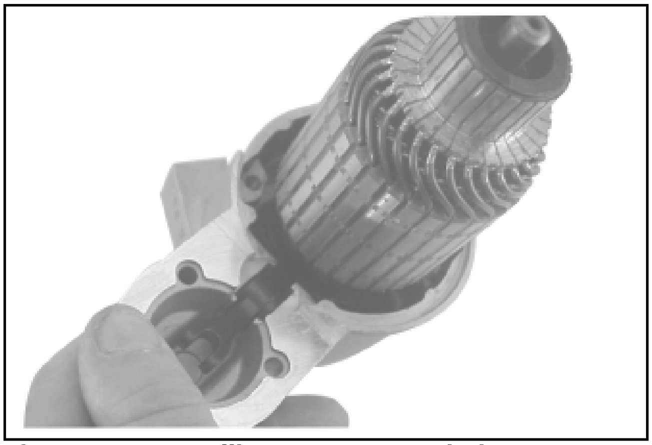

Figure 8-59. Installing Armature and Pivot Lever.

7. Install the backup washer, followed by the rubber grommet, into the matching recess of the drive end cap. The molded recesses in the grommet should be "out", matching and aligned with those in the end cap. See Figure 8-60.

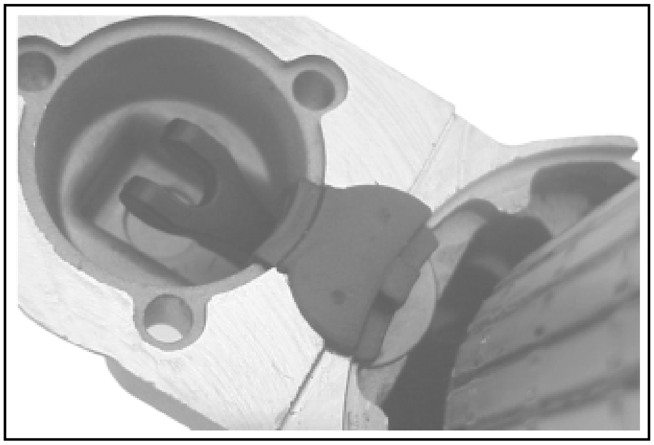

Figure 8-60. Installing Backup Washer and Grommet.

8. Install the frame, with the small notch forward, onto the armature and drive end cap. Align the notch with the corresponding section in the rubber grommet. Install the drain tube in the rear cutout, if it was removed previously. See Figure 8-61.

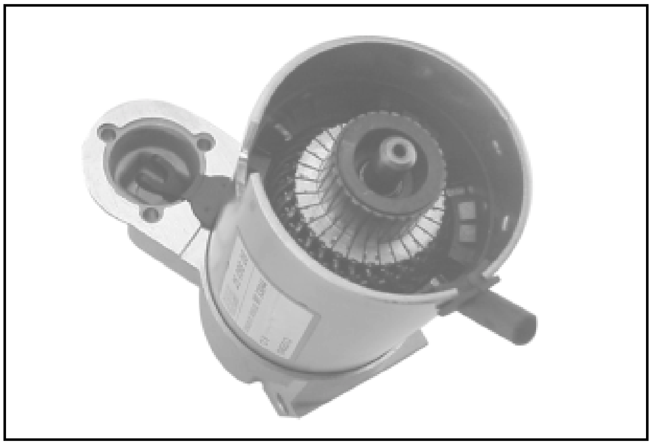

Figure 8-61. Installing Frame and Drain Tube.

9. Install the flat thrust washer onto the commutator end of the armature shaft. See Figure 8-62.

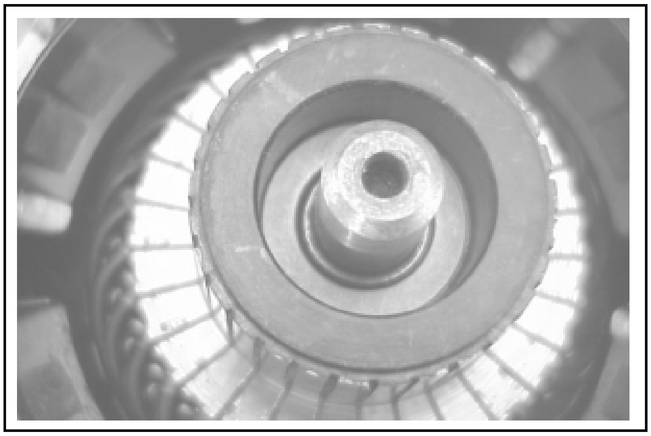

Figure 8-62. Installing Thrust Washer.

10. Starter reassembly when **replacing** the Brushes/ Brush Holder Assembly:

    a. Hold the starter assembly vertically on the end housing, and carefully position the assembled brush holder assembly, with the supplied protective tube, against the end of the commutator/armature. The mounting screw holes in the metal clips must be "up/out." Slide the brush holder assembly down into place around the commutator, and install the positive (+) brush lead grommet in the cutout of the frame. See Figure 8-63. The protective tube may be saved and used for future servicing.

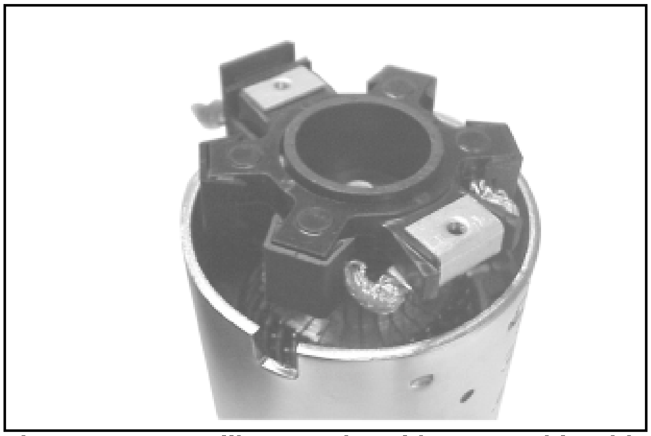

Figure 8-63. Installing Brush Holder Assembly with Supplied Tube.

Starter reassembly when **not replacing** the Brushes/ Brush Holder Assembly:

a. Carefully unhook the retaining caps from over each of the brush assemblies. Do not lose the springs.

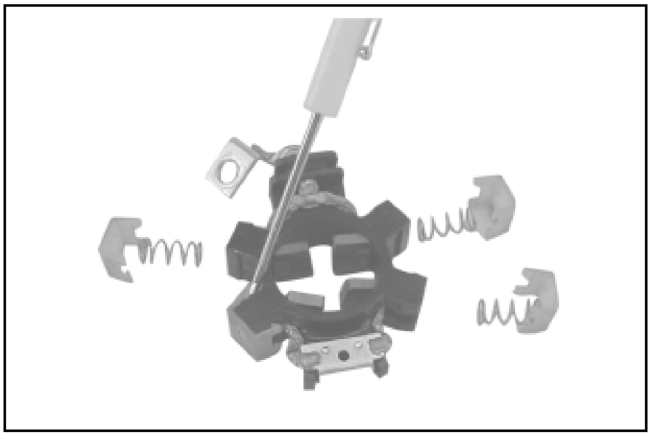

Figure 8-64. Removing Retaining Clips.

b. Position each of the brushes back in their slots so they are flush with the I.D. of the brush holder assembly. Insert the Brush Installation Tool (SPX Part No. KO3226-1 with extension), or use the tube described above from a prior brush installation, through the brush holder assembly, so the holes in the metal mounting clips are "up/out."

c. Install the brush springs and snap on the four retainer caps. See Figure 8-65.

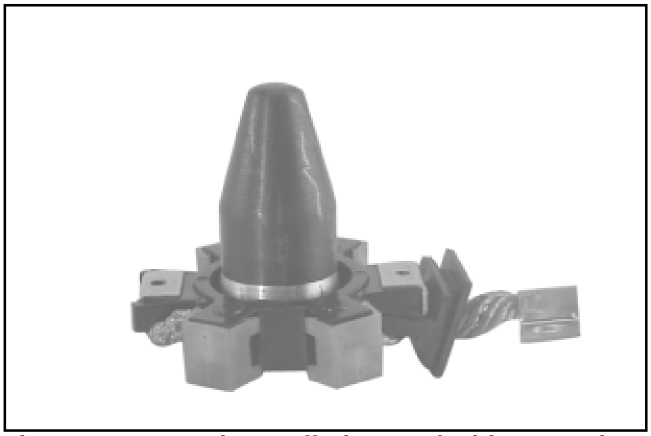

Figure 8-65. Brush Installation Tool with Extension.

d. Hold the starter assembly vertically on the end housing, and carefully place the tool (with extension) and assembled original brush holder assembly onto the end of the armature shaft. Slide the brush holder assembly down into place around the commutator, install the positive (+) brush lead grommet in the cutout of the frame. See Figure 8-66.

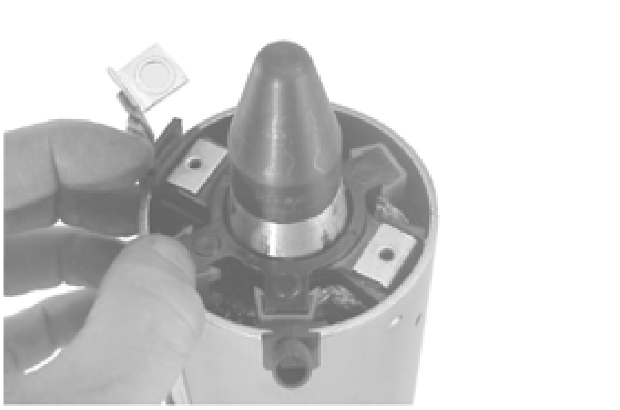

Figure 8-66. Installing Brush Holder Assembly using Tool with Extension.

11. Install the end cap onto the armature and frame, aligning the thin raised rib in the end cap with the corresponding slot in the grommet of the positive (+) brush lead.

12. Install the two thru bolts, and the two brush holder mounting screws. Torque the thru bolts to **5.6-9.0 N·m (49-79 in. lb.)**. Torque the brush holder mounting screws to **2.5-3.3 N·m (22-29 in. lb.)**. See Figures 8-67 and 8-68.

Figure 8-67. Torquing Thru Bolts.

Figure 8-68. Torquing Brush Holder Screws.

13. Hook the plunger behind the upper end of the drive lever, and install the spring into the solenoid. Insert the three mounting screws through the holes in the drive end cap. Use these to hold the solenoid gasket in position, then mount the solenoid. Torque the screws to **4.0-6.0 N·m (35-53 in. lb.)**.

14. Connect the positive (+) brush lead/bracket to the solenoid and secure with the hex. nut. Torque the nut to **8-11 N·m (71-97 in. lb.)**. Do not overtighten. See Figure 8-69.

Figure 8-69. Positive (+) Brush Lead Connection.

Section 9
Disassembly

WARNING: Accidental Starts!
Disabling engine. Accidental starting can cause severe injury or death. *Before working on the engine or equipment, disable the engine as follows: 1) Disconnect the spark plug lead(s). 2) Disconnect negative (-) battery cable from battery.*

General

Clean all parts thoroughly as the engine is disassembled. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully.

Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Typical Disassembly Sequence

The following sequence is suggested for complete engine disassembly. The sequence can be varied to accommodate options or special equipment.

1. Disconnect spark plug leads.
2. Shut off fuel supply.
3. Drain oil from crankcase and remove oil filter.
4. Remove muffler.
5. Remove air cleaner assembly.
6. Remove control panel (if so equipped).
7. Remove fuel pump.
8. Remove throttle controls.
9. Remove external governor controls.
10. Remove carburetor.
11. Remove electric starter motor.
12. Remove outer baffles and blower housing.
13. Remove Oil Sentry™ (if so equipped).
14. Remove inner baffles and breather cover.
15. Remove valve covers.
16. Remove ignition modules.
17. Remove intake manifold.
18. Remove spark plugs.
19. Remove cylinder heads and hydraulic lifters.
20. Remove grass screen and fan.
21. Remove flywheel.
22. Remove stator and backing plates.
23. Remove closure plate assembly.
24. Remove camshaft.
25. Remove connecting rods with pistons and rings.
26. Remove crankshaft.
27. Remove governor cross shaft.

Disconnect Spark Plug Leads

1. Disconnect the leads from the spark plugs. See Figure 9-1.

   NOTE: Pull on boot only, to prevent damage to spark plug lead.

Figure 9-1. Disconnect Both Spark Plug Leads.

Shut Off Fuel Supply

Drain Oil from Crankcase and Remove Oil Filter

1. Remove the oil fill cap and dipstick and one of the oil drain plugs.

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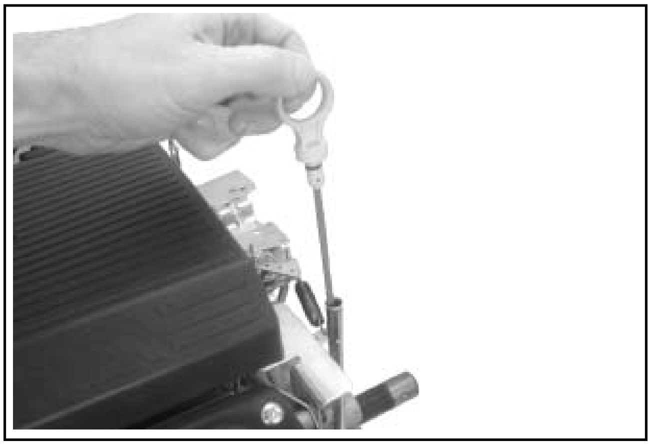


Figure 9-2. Removing Dipstick from Tube.

Figure 9-3. Removing Oil Fill Cap from Cover.

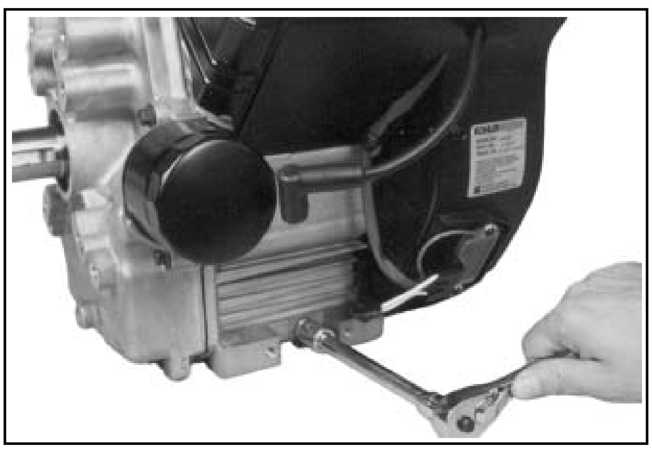


Figure 9-4. Removing Oil Drain Plug.

2. Allow ample time for the oil to drain from the crankcase and oil filter.

3. Remove and discard the oil filter. See Figure 9-5.

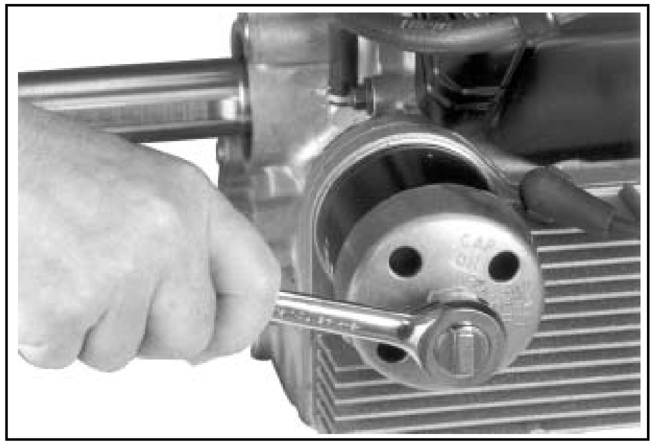


Figure 9-5. Removing Oil Filter.

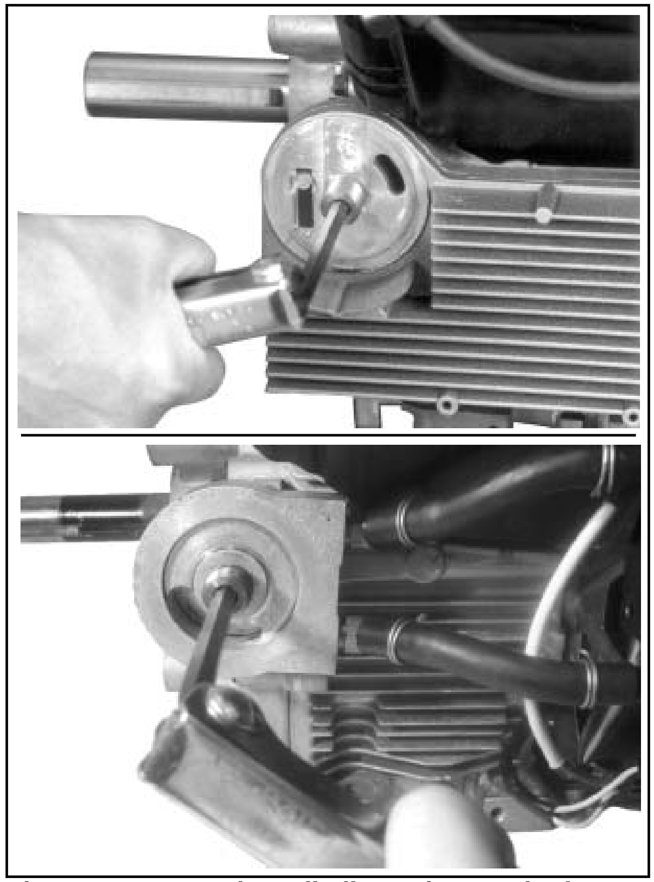


Figure 9-6. Removing Oil Filter Adapter Nipple.

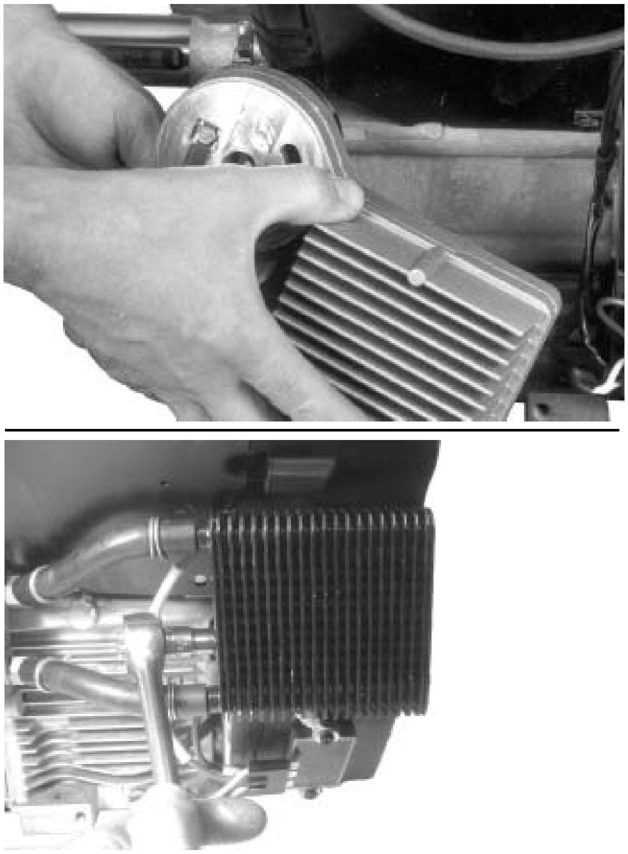


Figure 9-7. Removing Oil Cooler.

4. An oil cooler is standard equipment on some models and an option on others. It may be a cast aluminum housing, part of the oil filter adapter, or attached to the blower housing, separated from the oil filter adapter. If so equipped, remove the adapter and the cooler. See Figures 9-6 and 9-7.

Remove Muffler

1. Remove the exhaust system and attaching hardware from the engine. On engines equipped with a port liner, remove it now.

Remove Air Cleaner Assembly

1. Unhook the latches or loosen the knob and remove the cover. Refer to Section 4.

2. Remove the wing nut from the element cover.

3. Remove the element cover, the air cleaner element with precleaner and the stud seal.

4. Remove the hex. flange screws securing the bracket and base. See Figure 9-8. Two additional rear screws must be removed if the engine contains a rear air cleaner support bracket. See Figure 9-9.

Figure 9-8. Removing Air Cleaner Base Retainer.

Figure 9-9. Rear Air Cleaner Bracket Screws.

5. Remove the bracket then remove the base and gasket while carefully pulling the rubber breather tube through the base. See Figure 9-10.

Figure 9-10. Removing Breather Tube from Base.

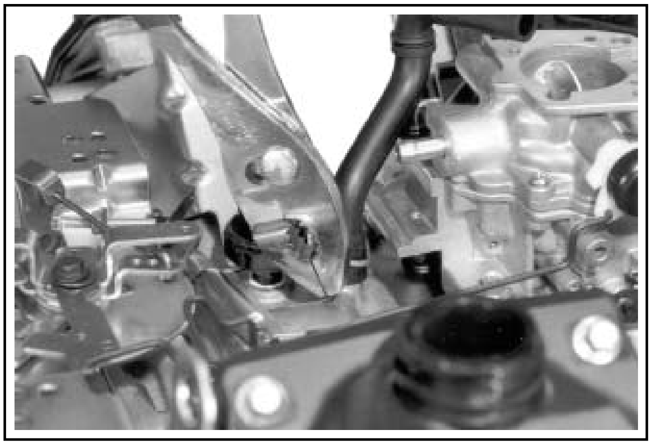


Figure 9-11. Removing Tube from Breather Cover.

6. Remove the rubber breather tube from the breather cover. See Figure 9-11.

Remove Fuel Pump

WARNING: Explosive Fuel!
Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

Pulse Style Pumps

1. Disconnect the fuel lines at the carburetor and at the in-line fuel filter. See Figure 9-12.

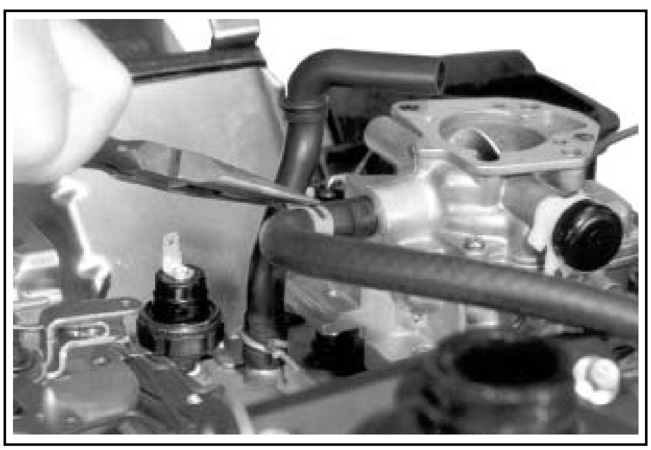


Figure 9-12. Disconnecting Fuel Inlet Line at Carburetor.

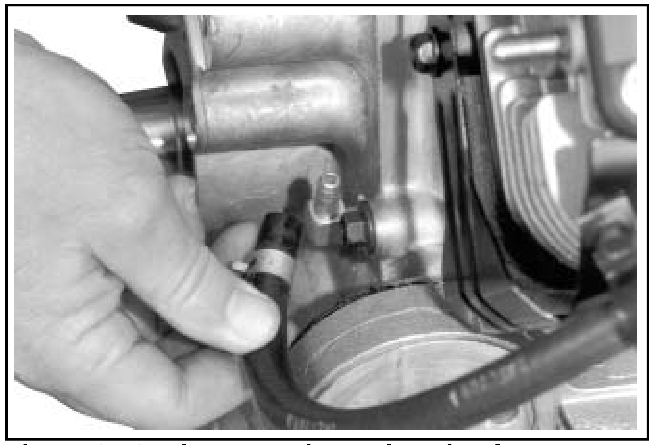


Figure 9-13. Disconnecting Pulse Line from Crankcase.

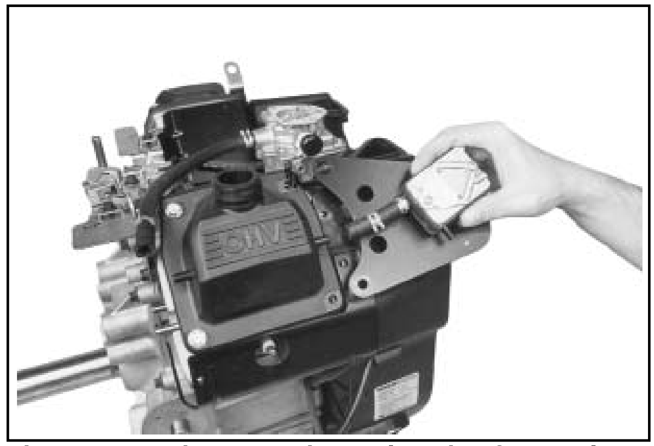


Figure 9-14. Disconnecting Pulse Line from Valve Cover (Early Models).

2. Disconnect the pulse (vacuum) line from the crankcase, or from the valve cover on earlier models. See Figures 9-13 and 9-14.

3. Remove the two hex. flange screws securing the fuel pump to the bracket or to the blower housing. See Figure 9-15. The fuel pump body may be metal or plastic.

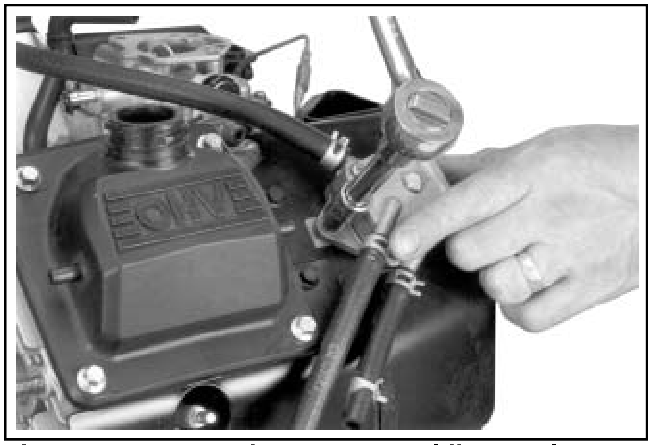


Figure 9-15. Removing Screws Holding Fuel Pump (Metal Bodied Pump Shown).

4. Note or mark the orientation of the fuel pump, then remove the fuel pump with lines attached as shown in Figure 9-16.

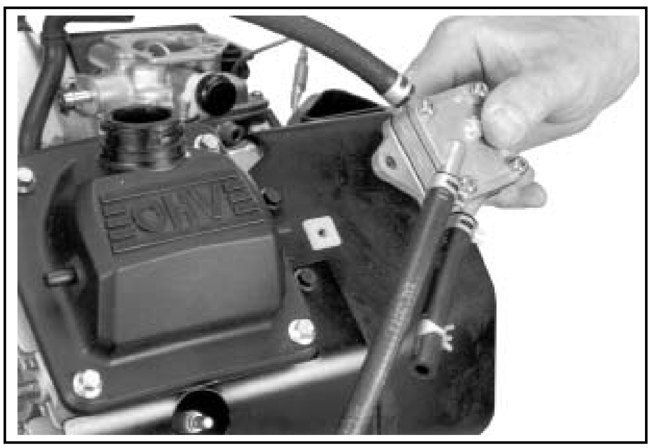


Figure 9-16. Remove Fuel Pump and Lines.

Mechanical Fuel Pump
The mechanical style fuel pump is part of the valve cover assembly. See Figure 9-17.

1. Disconnect the fuel lines at the pump outlet and at the in-line fuel filter.

2. The fuel pump will be removed with the valve cover. Refer to the valve cover removal procedure.

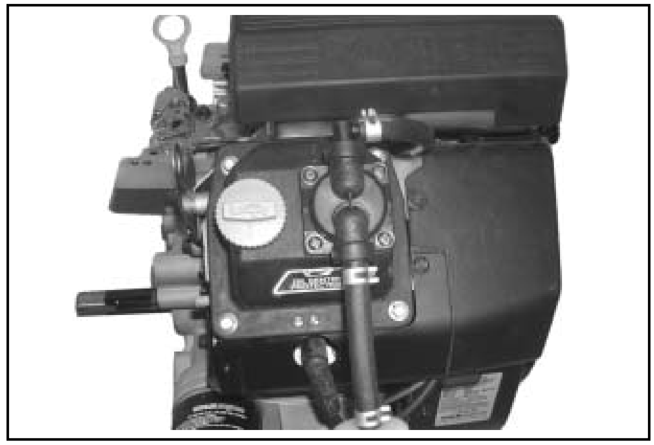


Figure 9-17. Mechanical Fuel Pump.

Remove Control Panel (If So Equipped)

1. Disconnect the Oil Sentry™ Indicator Light wires.

2. Disconnect the choke control cable from the control bracket.

3. Disconnect the throttle control cable or shaft.

4. Remove the panel from the blower housing.

Remove Throttle & Choke Controls

1. Remove the four hex. flange screws securing the control bracket and rear air cleaner bracket (some models) to the cylinder heads. See Figures 9-18 and 9-19.

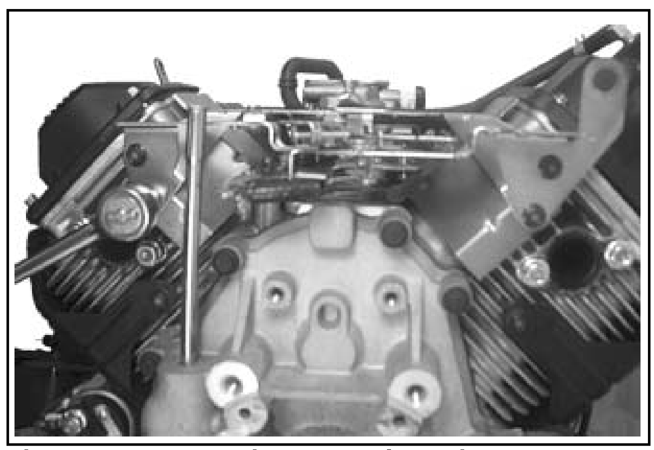


Figure 9-18. Removing Control Bracket.

Figure 9-19. Rear Air Cleaner Bracket (Some Models).

2. Mark the spring hole locations and disconnect the spring from the governor lever. See Figure 9-20.

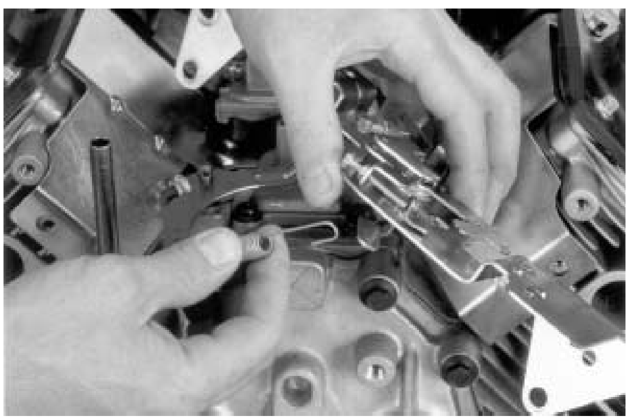


Figure 9-20. Disconnecting Spring from Bracket.

3. Remove the choke linkage from the choke actuator lever and carburetor. See Figure 9-21.

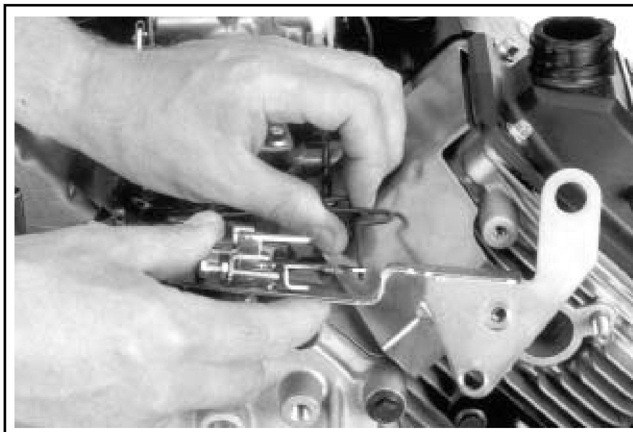


Figure 9-21. Disconnecting Choke Linkage from Actuator Lever.

Remove External Governor Controls

1. Loosen the hex. flange nut and remove the governor lever from the cross shaft. See Figure 9-22. Leave lever attached to the throttle linkage and lay assembly on the top of the crankcase.

Figure 9-22. Removing Governor Lever.

Remove Carburetor

⚠ WARNING: Explosive Fuel!

Gasoline is extremely flammable and its vapors can explode if ignited. Store gasoline only in approved containers, in well ventilated, unoccupied buildings, away from sparks or flames. Do not fill the fuel tank while the engine is hot or running, since spilled fuel could ignite if it comes in contact with hot parts or sparks from ignition. Do not start the engine near spilled fuel. Never use gasoline as a cleaning agent.

1. Disconnect the fuel shut-off solenoid lead if so equipped.

2. Remove the two carburetor mounting screws. See Figure 9-23.

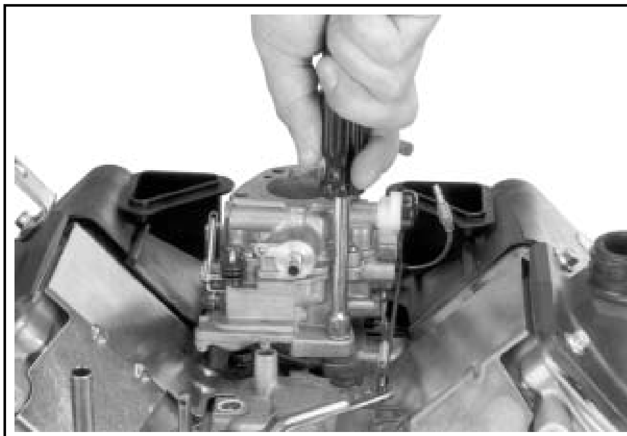


Figure 9-23. Removing Carburetor Mounting Screws.

3. Remove the carburetor, throttle linkage and governor lever as an assembly. See Figure 9-24.

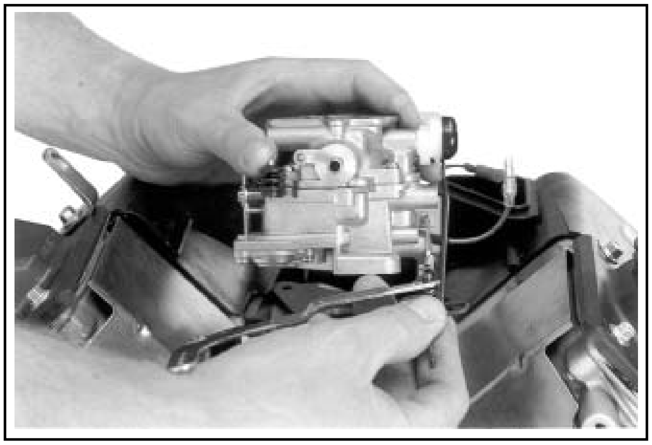


Figure 9-24. Removing Carburetor Assembly with Governor Lever Attached.

4. Remove the carburetor gasket.

5. If necessary, the carburetor, throttle linkage and governor lever can be separated. Reattach the bushings to the linkage following separation to avoid losing them.

Remove Oil Sentry™ (If So Equipped)

1. Disconnect the lead from the Oil Sentry™ switch.

2. Remove the Oil Sentry™ switch from the breather cover. See Figure 9-25.

Figure 9-25. Removing Oil Sentry™ Switch from Breather Cover.

Remove Electric Starter Motor

1. Disconnect the leads from the starter.

2. Remove the two hex. flange screws. See Figure 9-26.

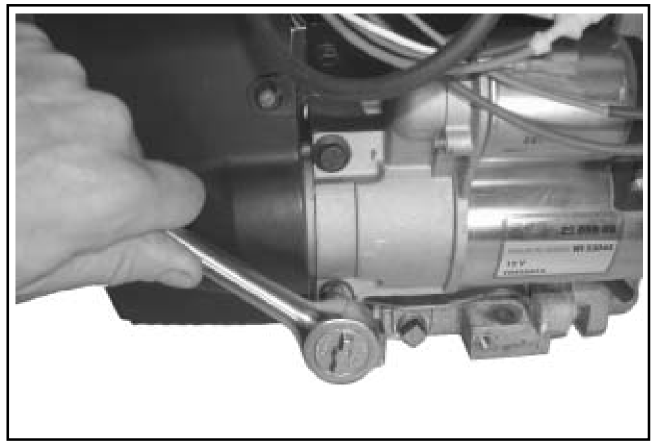


Figure 9-26. Removing Electric Starter Motor.

3. Remove the starter assembly and any spacers (if used).

Remove Outer Baffles and Blower Housing

1. Disconnect the plug from the rectifier-regulator on the blower housing. See Figure 9-27.

Figure 9-27. Disconnecting Plug from Rectifier-Regulator.

2. Use the tip of the dipstick or a similar small flat tool to bend the locking tang, then remove the B+ (center lead) from the terminal plug as shown in Figure 9-28. This will allow the blower housing to be removed without disturbing the wiring harness.

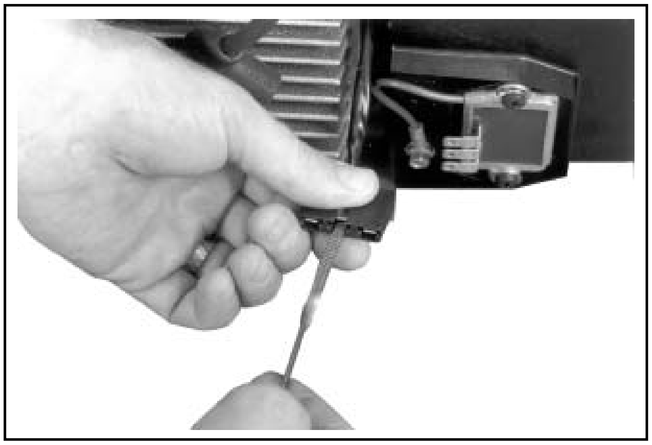


Figure 9-28. Remove B+ Lead from Terminal Plug.

3. The rectifier-regulator does not have to be detached from the blower housing. If the engine is equipped with SMART-SPARK™ the SAM module should be removed from the cylinder baffle or blower housing. See Figure 9-29. The module willing hang loose as part of the wiring harness.

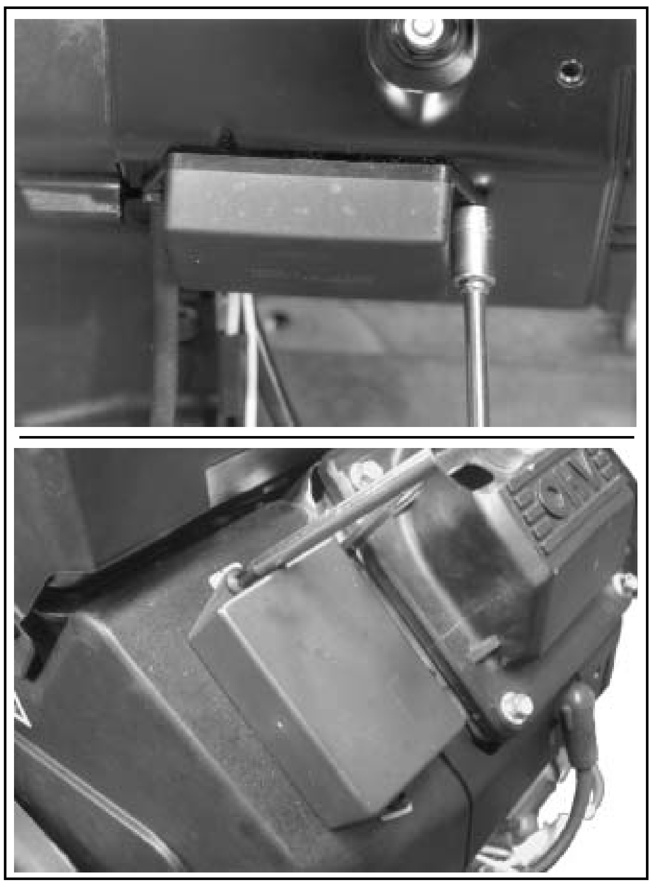


Figure 9-29. Removing the Spark Advance Module (Applicable Models).

4. Remove the three (each side) hex. flange screws securing the outer baffles. Note the location of any lifting strap and position of the two short screws (one each side on bottom) for reassembly. See Figure 9-30.

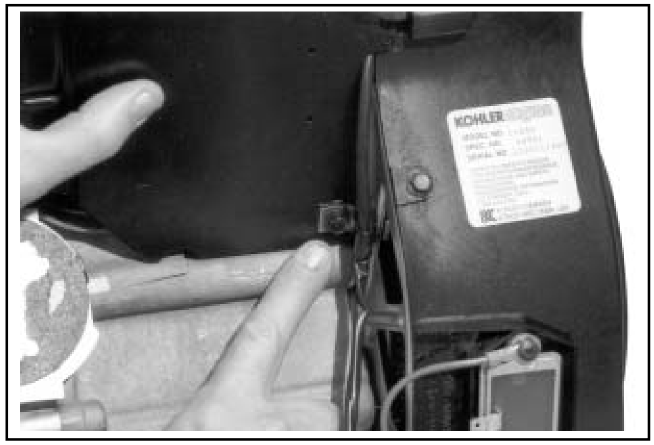


Figure 9-30. Note Location of Two Short Screws.

Figure 9-31. Removing Outer Baffles.

5. Remove the outer baffles on both sides. See Figure 9-31.

6. On engines equipped with a metal grass screen, remove the screen before removing the blower housing. See Figure 9-32. Plastic grass screens can be removed after the blower housing is removed.

Figure 9-32. Removing Metal Grass Screen.

7. Remove the lower blower housing screw and washer securing the rectifier-regulator ground lead or grounding strap.

8. Remove the remaining hex. flange screws and detach the blower housing. See Figure 9-33.

9. Disconnect the plug from the key switch in the blower housing if engine is so equipped.

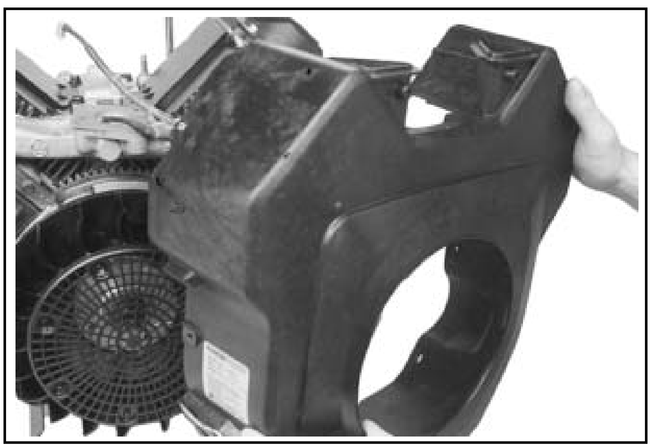


Figure 9-33. Removing Blower Housing.

Remove Inner Baffles and Breather Cover

The inner (valley) baffles are attached at one corner using the same fasteners as the breather cover. See Figure 9-34.

1. Remove the two hex. flange screws securing the inner baffles.

Figure 9-34. Removing Fasteners Holding Baffle and Breather Cover.

2. Remove both inner baffles. See Figure 9-35.

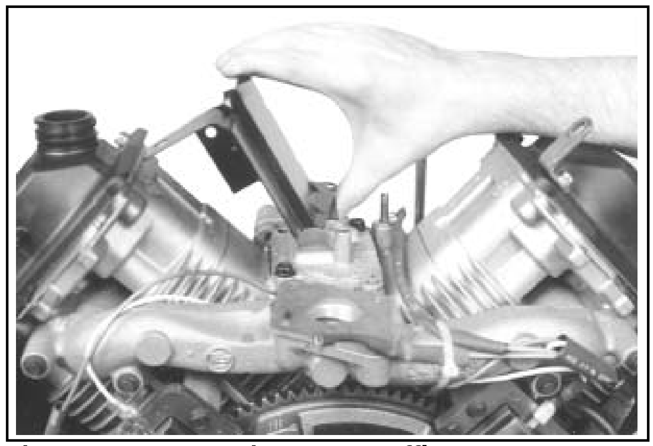


Figure 9-35. Removing Inner Baffles.

3. Remove the two remaining screws holding the breather cover to the crankcase. See Figure 9-35.

4. Pry under the protruding edge of the breather cover with a screwdriver to break the RTV or gasket seal. See Figure 9-36. Do not pry on the sealing surfaces as it could cause damage resulting in leaks. Most engines use a formed gasket rather than RTV sealant.

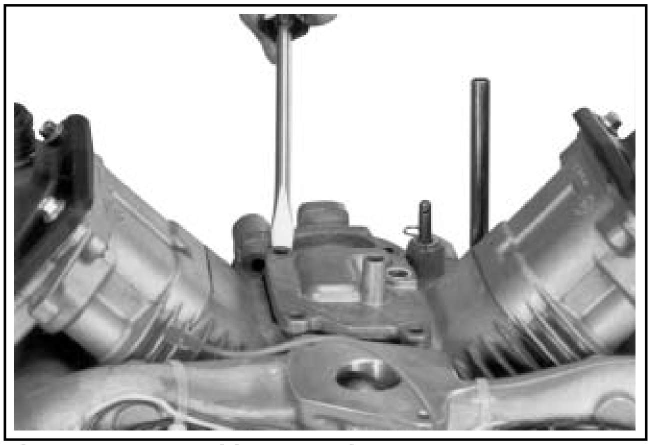


Figure 9-36. Breaking Breather Cover Seal.

5. Remove the breather cover and gasket (if used). See Figure 9-37.

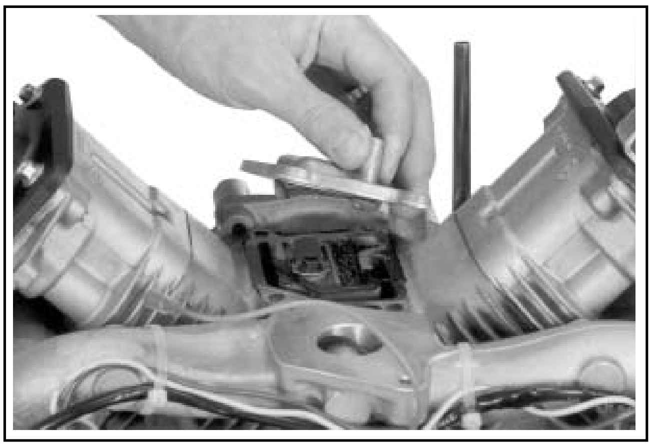


Figure 9-37. Removing Breather Cover.

6. Remove the breather filter from chamber. See Figure 9-38.

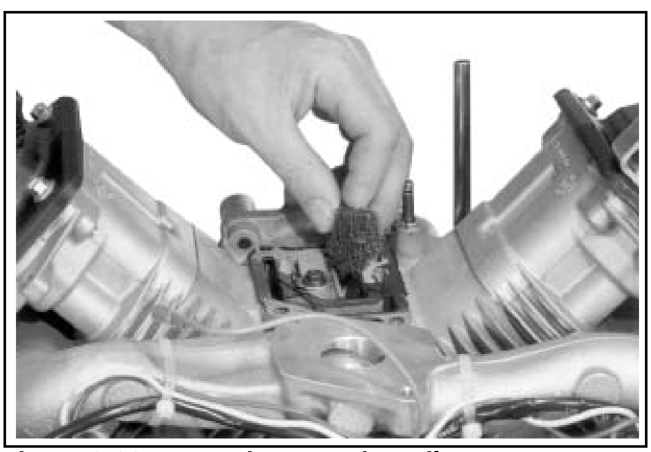


Figure 9-38. Removing Breather Filter.

7. Remove the hex. flange screw, breather reed retainer and breather reed. See Figure 9-39.

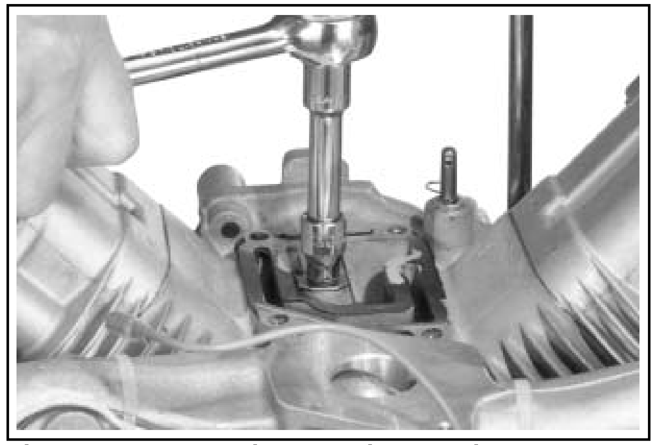


Figure 9-39. Removing Breather Reed.

Remove Valve Covers

Three valve cover designs have been used. The earliest type used a gasket and RTV sealant between the cover and sealing surface of the cylinder head. The second type had a black O-Ring installed in a groove on the underside of the cover and may have metal spacers in the bolt holes. The latest design uses a brown O-Ring, and the bolt holes spacers are molded in place.

1. Remove the four hex. flange screws securing each valve cover. Note the position of any attached brackets or lifting straps.

2. Remove the valve covers, valve cover gaskets or O-Rings and any brackets or lifting straps. Note which side of the engine has the oil fill and or fuel pump valve cover. See Figure 9-40.

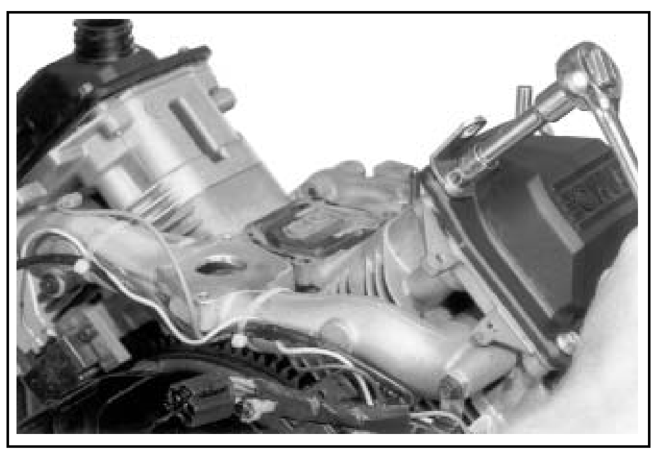


Figure 9-40. Removing Valve Covers.

Remove Ignition Modules

1. Disconnect the lead(s)* from each ignition module. See Figure 9-41. *Modules for non-SMART-SPARK™ ignition systems have only one kill lead.

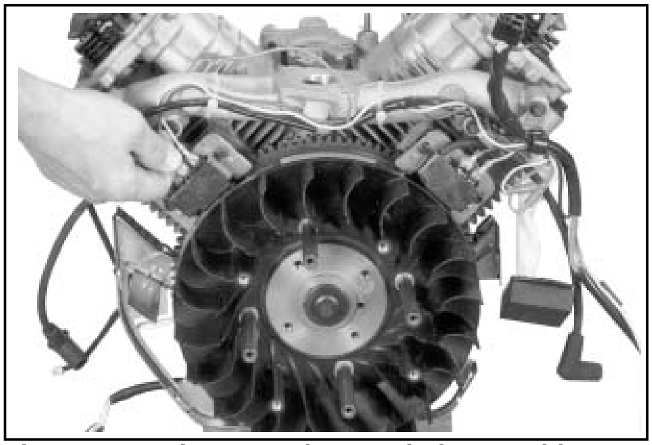


Figure 9-41. Disconnecting Leads from Ignition Modules.

2. Rotate the flywheel so the magnet is away from the modules.

3. Remove the mounting screws and ignition modules. Note the position of ignition modules.

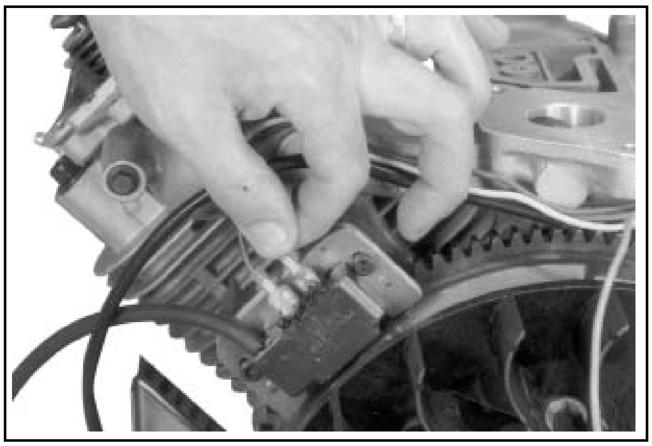


Figure 9-42. Position of SMART-SPARK™ Ignition Module.

Remove Intake Manifold

1. Remove the four hex. flange screws securing the intake manifold to the cylinder heads. Note which screws hold the wiring clamps.

2. Remove the intake manifold and the intake manifold gaskets (aluminum intake manifolds) or O-Rings (plastic intake manifolds). See Figure 9-43.

3. Leave the wiring harness attached to the manifold.

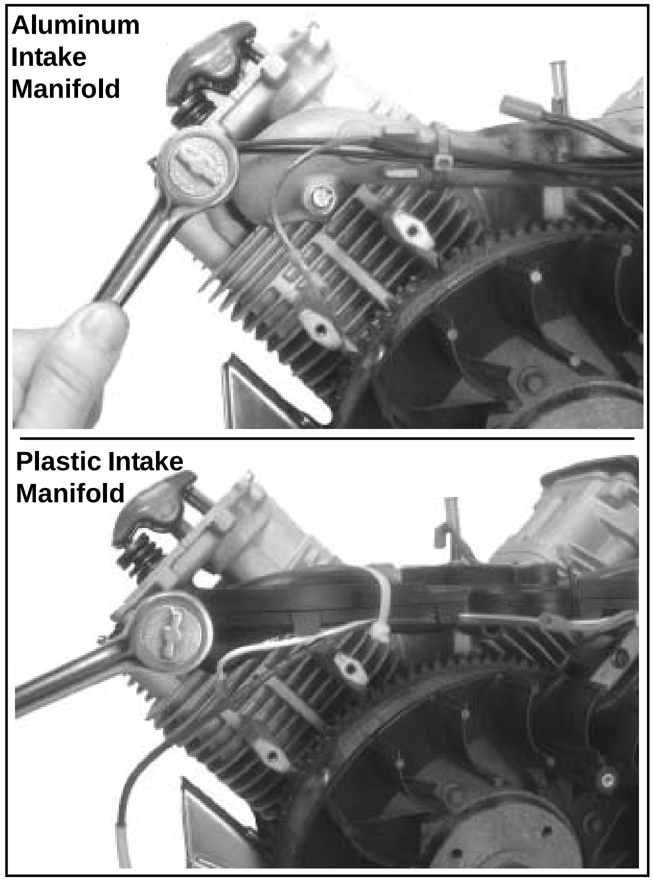


Figure 9-43. Removing Intake Manifold.

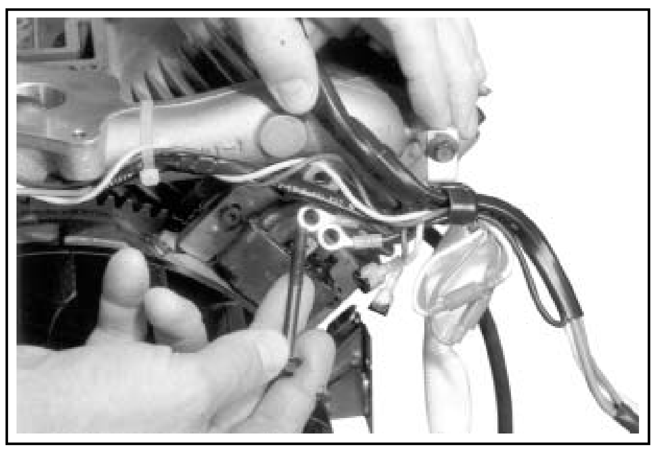


Figure 9-44. Bolt Wiring Harness Detail.

Remove Spark Plugs

1. Remove the spark plug from each cylinder head.

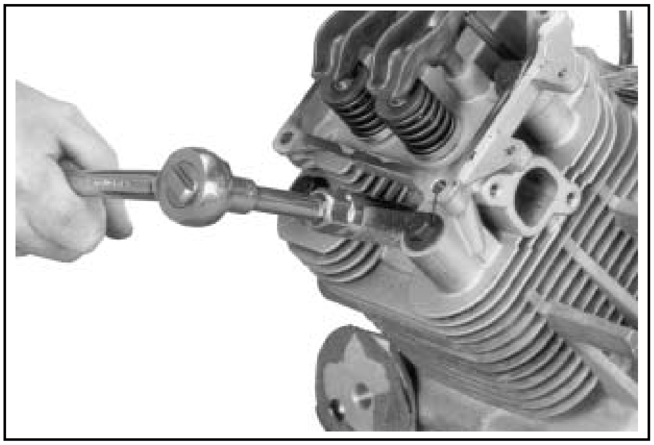


Figure 9-45. Removing Spark Plugs.

Remove Cylinder Heads and Hydraulic Lifters

NOTE: Cylinder heads are retained using either hex. flange screws or hex. flange nuts and washers on studs. Do not interchange or mix components, as the cylinder heads may have different machining, unique to each fastening method.

1. Remove the four hex. flange screws or hex. nuts and washers securing each cylinder head. See Figure 9-46. Discard the screws or nuts and washers once removed. Do not reuse. Studs (if present) should only be removed if damaged or if cylinder reconditioning is necessary. Once removed, they must be replaced.

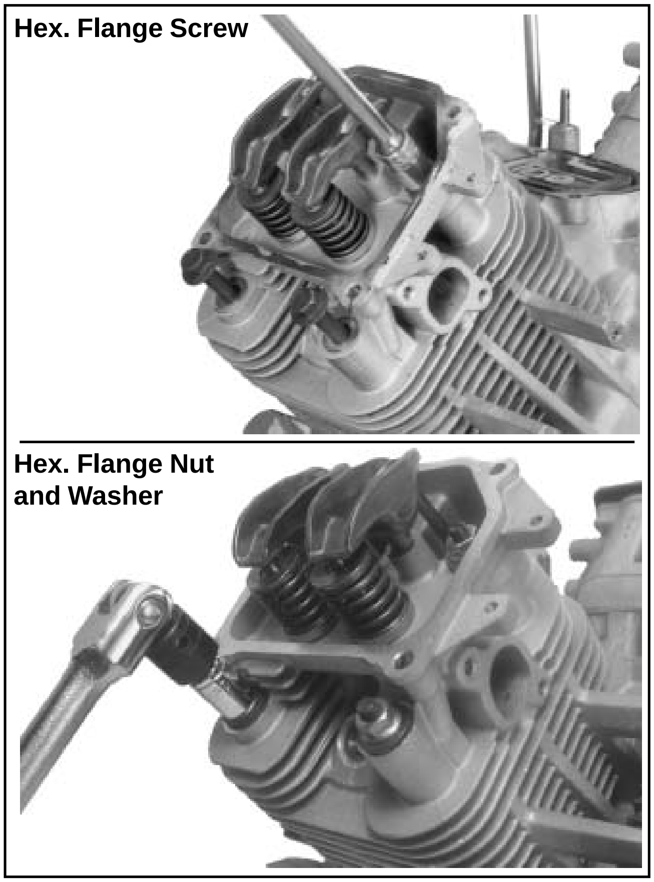


Figure 9-46. Removing Cylinder Head Fasteners.

2. Mark the position of the push rods as either intake or exhaust and cylinder 1 or 2. Push rods should always be reinstalled in the same positions.

3. Carefully remove the push rods, cylinder heads and head gaskets. See Figure 9-47.

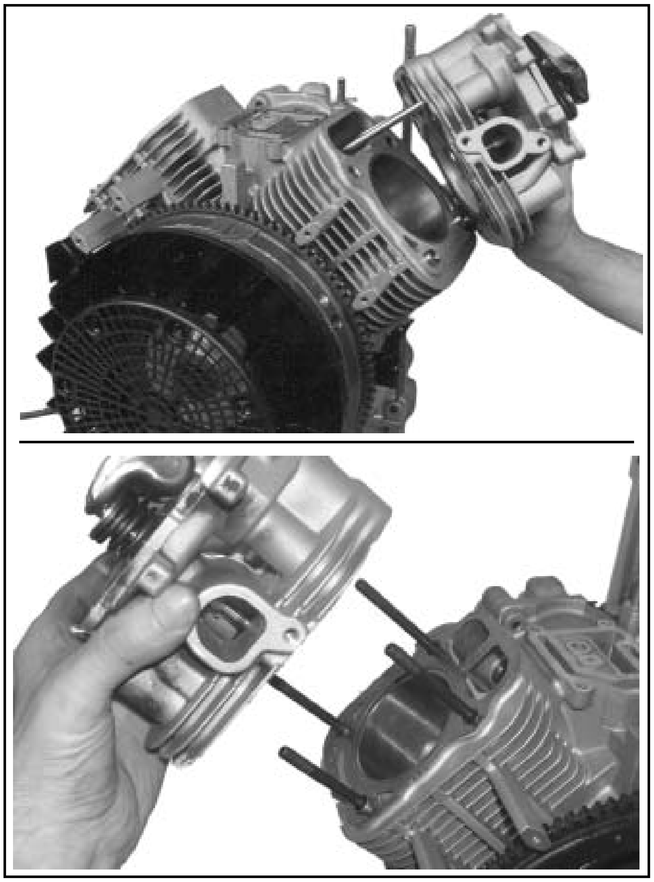


Figure 9-47. Removing Cylinder Head Assembly.

4. Remove the lifters from the lifter bores. Use Hydraulic Lifter Tool (SPX Part No. KO1044) Do not use a magnet to remove lifters. Mark the lifters by location, as either intake or exhaust and cylinder 1 or 2. Hydraulic lifters should always be reinstalled in the same position. See Figures 9-48 and 9-49.

NOTE: The exhaust lifters are located on the output shaft side of the engine while the intake lifters are located on the fan side of the engine. The cylinder head number is embossed on the outside of each cylinder head. See Figure 9-50.

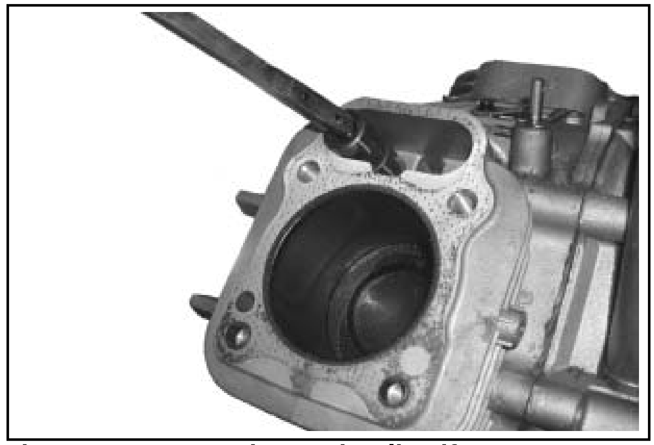


Figure 9-48. Removing Hydraulic Lifter.

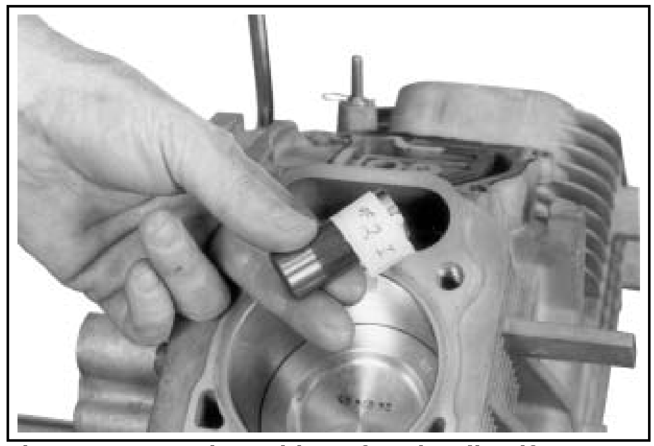


Figure 9-49. Mark Position of Hydraulic Lifters.

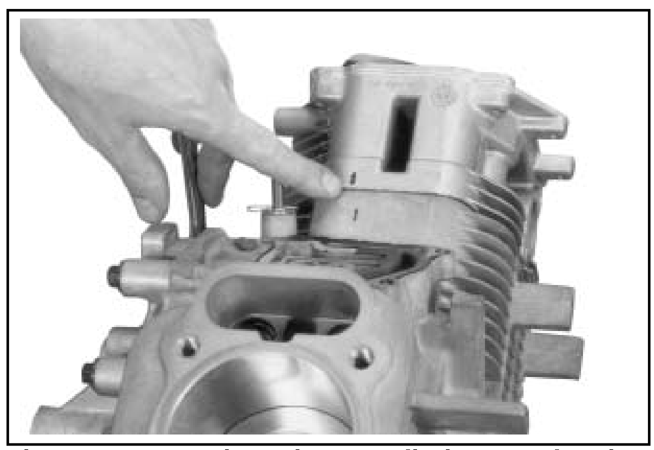


Figure 9-50. Match Marks on Cylinder Barrel and Heads.

Disassemble Cylinder Heads

1. Remove the two hex. flange screws, rocker arm pivots and rocker arms from the cylinder head. See Figure 9-51.

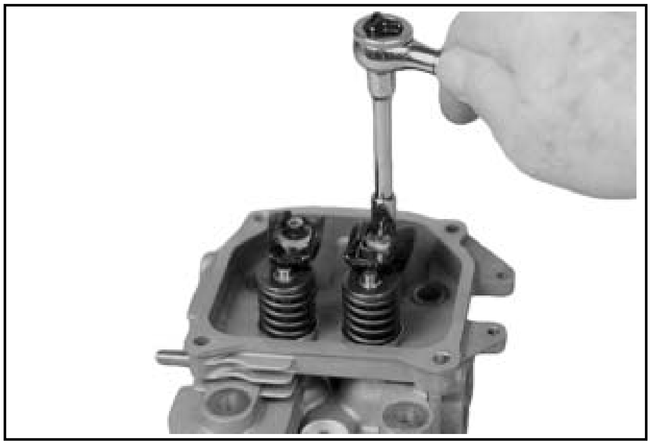


Figure 9-51. Removing Rocker Arms.

2. Compress the valve springs using a valve spring compressor. See Figure 9-52.

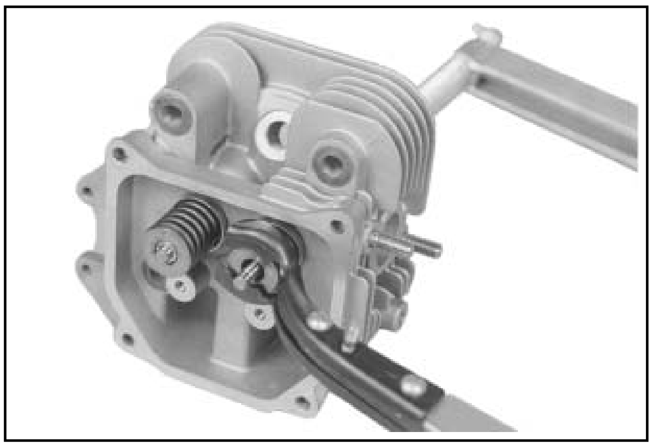


Figure 9-52. Removing Valves with Valve Spring Compressor.

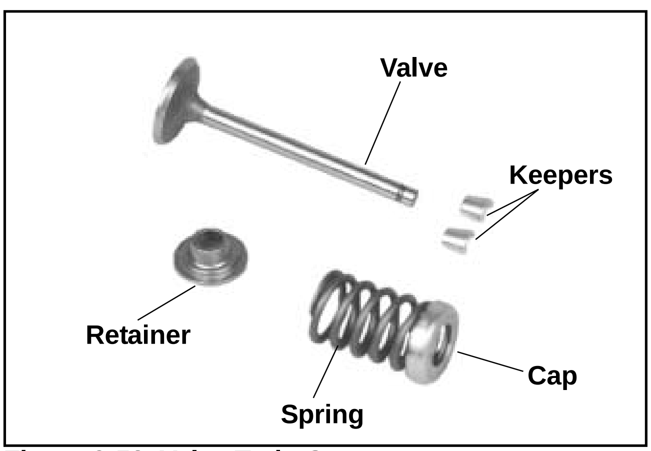


Figure 9-53. Valve Train Components.

3. Once the valve spring is compressed, remove the following items. See Figures 9-53 and 9-54.

- Valve spring keepers
- Valve spring retainers
- Valve springs
- Valve spring caps
- Intake and exhaust valves (mark position)
- Valve stem seals (intake valve only)

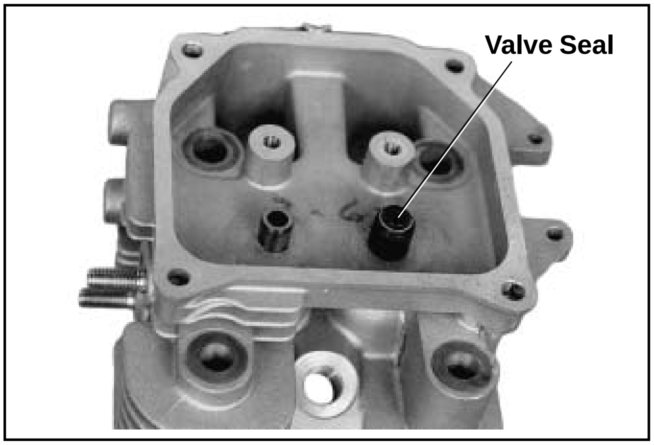


Figure 9-54. Intake Valve Seal Location.

NOTE: These engines use valve stem seals on the intake valves. Use a new seal whenever valve is removed or if the seal is deteriorated in any way. Never reuse an old seal.

4. Repeat the above procedure for the other cylinder head. Do not interchange parts from one cylinder head to the other.

Remove Grass Screen and Fan

1. Small metal retainers are typically attached on three of the seven mounting posts for positive retention of the plastic grass screen. Use a hook-end tool next to the post and pull outward to separate each of the small metal retainers. Then unsnap the fan from the remaining mounting posts. See Figure 9-55.

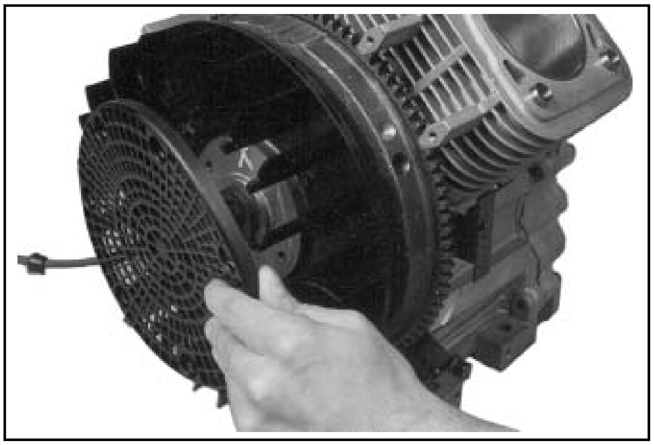


Figure 9-55. Removing Plastic Type Grass Screen.

2. Remove the four hex. flange screws and fan. See Figure 9-56.

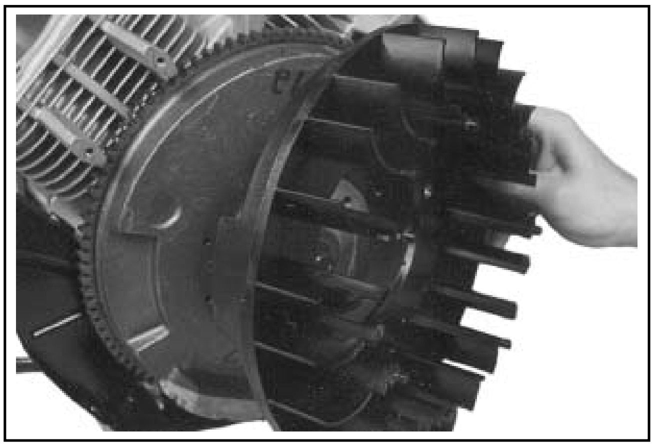


Figure 9-56. Removing Fan.

Remove Flywheel

1. Use a flywheel strap wrench or holding tool (see Section 2) to hold the flywheel and loosen the hex. flange screw securing the flywheel to the crankshaft. See Figure 9-57.

   NOTE: Always use a flywheel strap wrench or holding tool to hold the flywheel when loosening or tightening the flywheel screw. **Do not** use any type of bar or wedge to hold the flywheel. Use of such tools could cause the flywheel to become cracked or damaged.

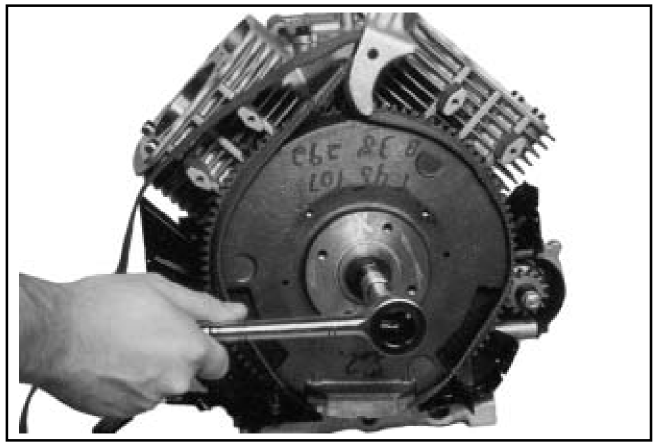


Figure 9-57. Removing Flywheel Fastener Using Strap Wrench.

2. Remove the hex. flange screw and washer.

3. Use a puller to remove the flywheel from the crankshaft. See Figure 9-58.

   NOTE: Always use a flywheel puller to remove the flywheel from the crankshaft. **Do not** strike the crankshaft or flywheel, as these parts could become cracked or damaged. Striking the puller or crankshaft can cause the crank gear to move, affecting the crankshaft end play.

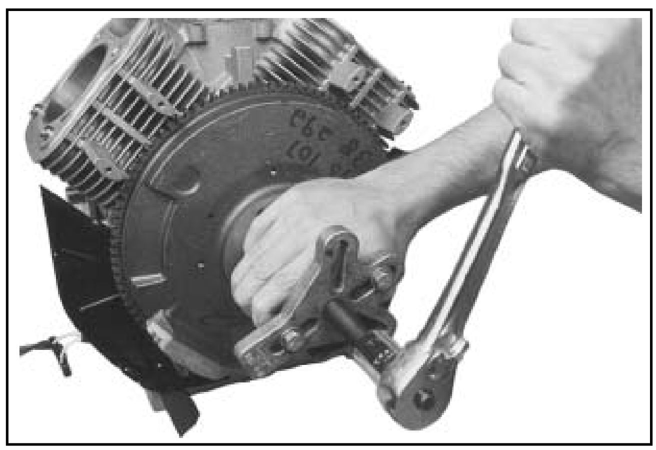


Figure 9-58. Removing Flywheel with a Puller.

4. Remove the woodruff key from the crankshaft.

Remove Stator and Backing Plates

1. Remove the four hex. flange screws securing the backing plates and stator wire bracket (if equipped). See Figure 9-59. Remove the backing plates and stator wire bracket.

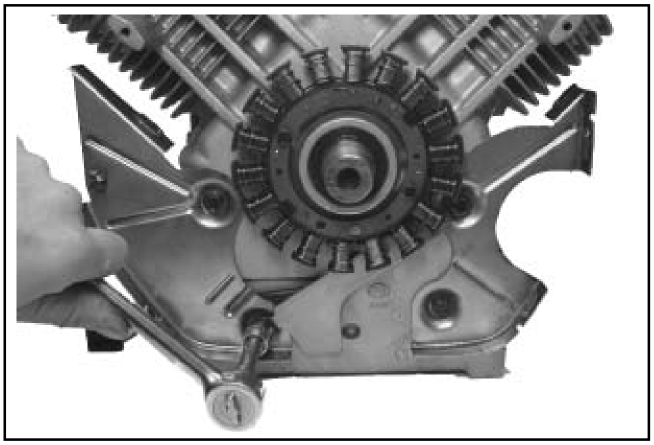


Figure 9-59. Removing Backing Plates and Stator Wire Bracket.

2. Remove the two hex. head screws and stator. See Figure 9-60. Note the routing of the stator lead in the channel.

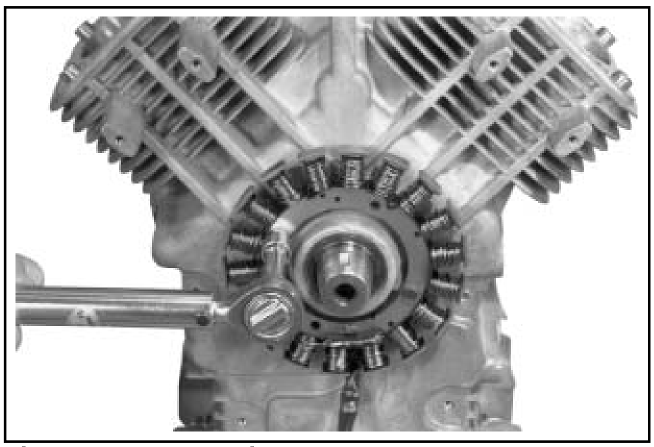


Figure 9-60. Removing Stator.

Remove Closure Plate Assembly

1. Remove the ten hex. flange screws securing the closure plate to the crankcase. See Figure 9-61.

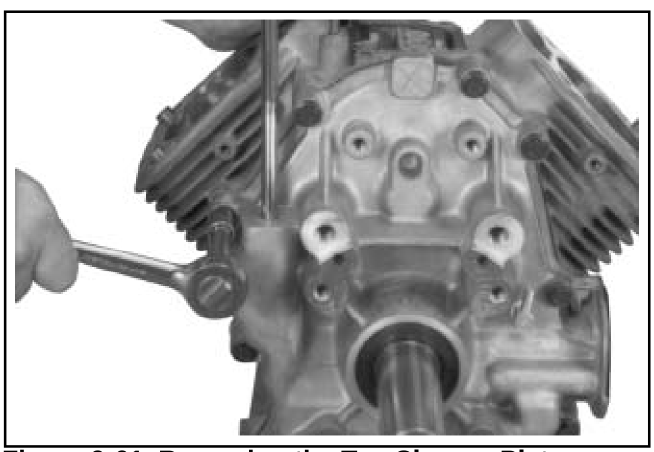


Figure 9-61. Removing the Ten Closure Plate Fasteners.

2. Locate the three splitting tabs that are cast into the perimeter of the closure plate. Insert the drive end of a 1/2" breaker bar between the top splitting tab and the crankcase. Hold the handle horizontal and pull toward you to break the RTV seal. If necessary, pry at the bottom tabs also. See Figures 9-62 and 9-63. Do not pry on the sealing surfaces as this could cause leaks. Carefully pull closure plate from crankcase.

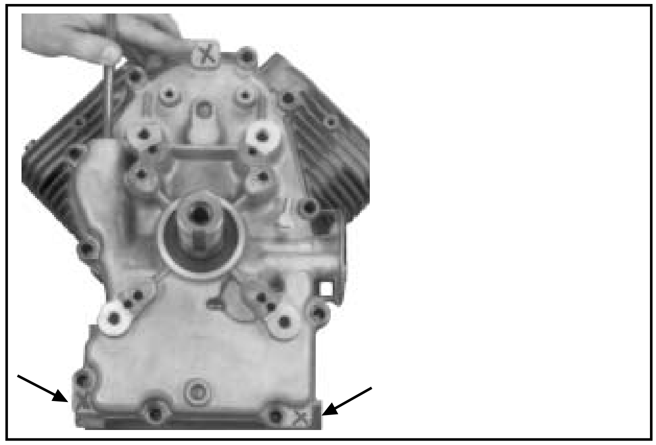


Figure 9-62. Location of Three Splitting Tabs.

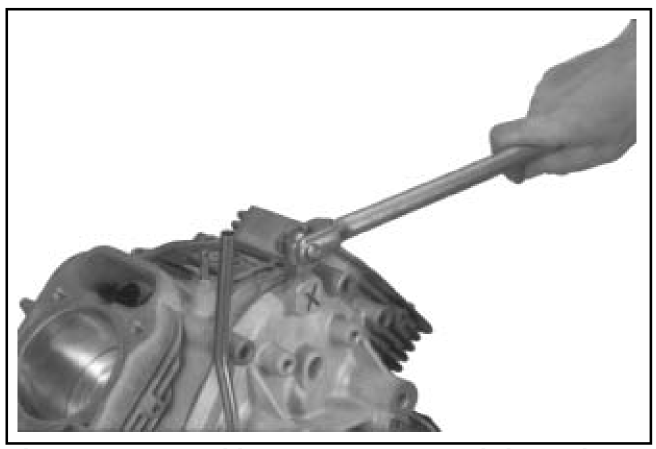


Figure 9-63. Breaking Seal on Top Splitting Tab.

Governor Gear Assembly

The governor gear assembly is located inside the closure plate. If service is required, refer to the service procedures under ‘‘Governor Gear Assembly’’ in Section 10.

Oil Pump Assembly

The oil pump is mounted to the inside of the closure plate. If service is required, refer to the service procedures under ‘‘Oil Pump Assembly’’ in Section 10.

Remove Camshaft

1. Remove the camshaft and shim. See Figure 9-64.

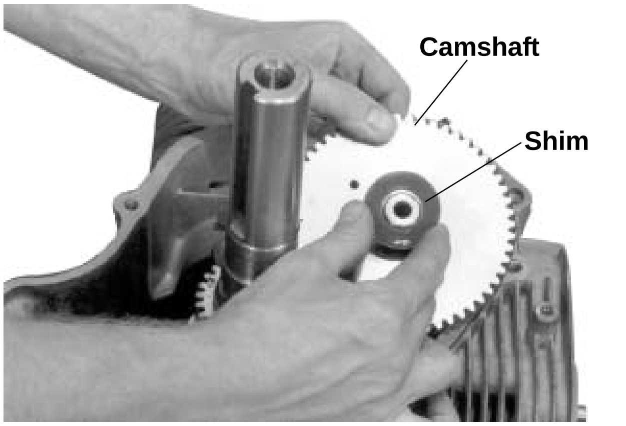


Figure 9-64. Removing Camshaft (Note Shim).

Remove Connecting Rods with Pistons and Rings

1. Remove the two hex. flange screws securing the closest connecting rod end cap. Remove the end cap. See Figure 9-65.

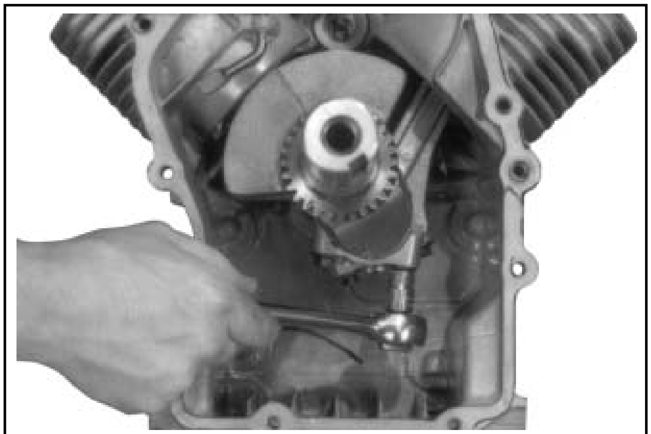


Figure 9-65. Removing Connecting Rod Bolts.

NOTE: If a carbon ridge is present at the top of either cylinder bore, use a ridge reamer tool to remove the ridge before attempting to remove the piston.

Figure 9-66. Mark End Cap with Cylinder Number Before Removal.

NOTE: The cylinders are numbered on the crankcase. Use the numbers to mark each end cap, connecting rod and piston for reassembly. **Do not** mix end caps and connecting rods.

Figure 9-67. Removing Piston/Connecting Rod Assemblies.

2. Carefully remove the connecting rod and piston assembly from the cylinder bore. See Figure 9-67.

3. Repeat the above procedures for the other connecting rod and piston assembly.

9

Remove Crankshaft

1. Carefully pull the crankshaft from the crankcase. See Figure 9-68. Note thrust washers and shims if used.

Figure 9-68. Removing Crankshaft.

Remove Governor Cross Shaft

1. Remove the hitch pin and plain washer, or the retainer and nylon washer, from the governor cross shaft. See Figures 9-69 and 9-70.

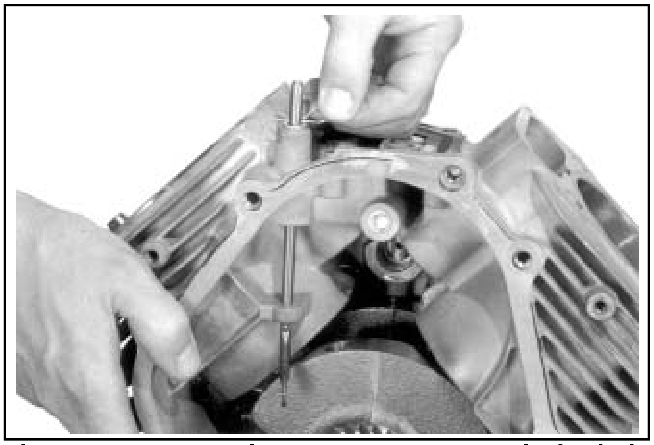


Figure 9-69. Removing Governor Cross Shaft Hitch Pin (6 mm Shaft Design).

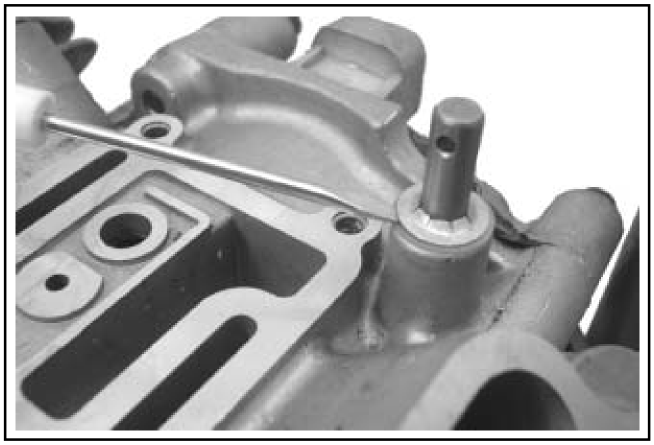


Figure 9-70. Removing Governor Cross Shaft Retainer (8 mm Shaft Design).

2. Pull the cross shaft with small washer out through the inside of the crankcase. See Figure 9-71.

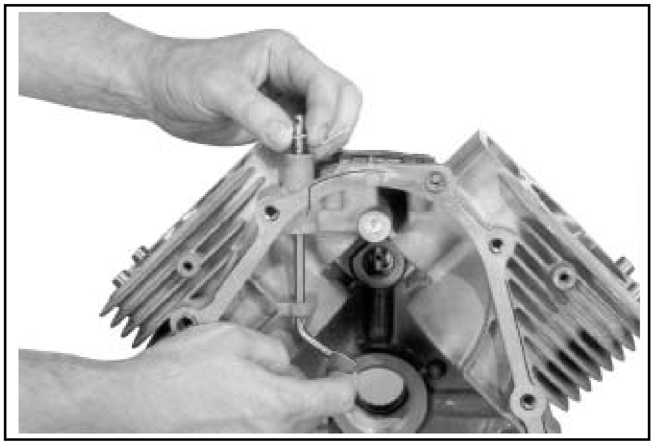


Figure 9-71. Pulling Governor Cross Shaft.

Remove Flywheel End Oil Seal

1. Remove oil seal from crankcase. See Figure 9-72.

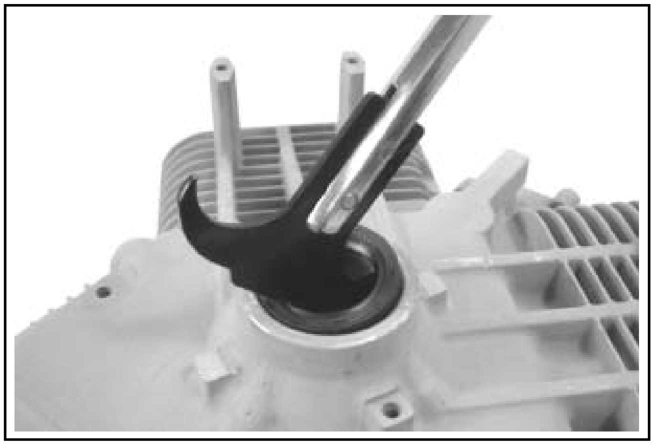


Figure 9-72. Removing Oil Seal.

Section 10
Inspection and Reconditioning

This section covers the operation, inspection, and repair/reconditioning of major internal engine components. The following components are not covered in this section. They are covered in sections of their own:

Air Cleaner, Section 4
Carburetor & External Governor, Section 5
Ignition, Charging & Electric Starter, Section 8

Clean all parts thoroughly. Only clean parts can be accurately inspected and gauged for wear or damage. There are many commercially available cleaners that will quickly remove grease, oil, and grime from engine parts. When such a cleaner is used, follow the manufacturer's instructions and safety precautions carefully. Make sure all traces of the cleaner are removed before the engine is reassembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Use an aerosol gasket remove, paint stripper, or lacquer thinner to remove any old sealant. Apply the solvent, allow time for it to work, and then brush the surface with a **brass** wire brush. After the old sealant is removed, clean the surface with isopropyl alcohol, lacquer thinner, or aerosol electrical contact cleaner. **Do not** scrape the surfaces, as any scratches, nicks, or burrs can result in leaks. See Service Bulletin 252 for further information.

Refer to A Guide to Engine Rebuilding (TP-2150-A) for additional information. Measurement Guide (TP-2159-B) and Engine Inspection Data Record (TP-2435) are also available; use these to record inspection results.

Automatic Compression Release (ACR)

Some engines are equipped with the optional Automatic Compression Release (ACR) mechanism. The ACR lowers compression at cranking speeds to make starting easier.

Operation

The ACR mechanism consists of a flyweight, spring and pivoting control pin assembly attached to the gear on the camshaft. At cranking speeds (700 RPM or lower), the control pin protrudes above the exhaust cam lobe. This pushes the exhaust valve off its seat during the first part of the compression stroke. The reduced compression results in an effective compression ratio of about 2:1 during cranking.

After starting, engine speed increases to over 700 RPM, and centrifugal force overcomes the force of the flyweight spring. The flyweight moves outward, pulling the arm of the control pin, so it pivots into the ''run'' position. The control pin no longer has any effect on the exhaust valve and the engine operates at full power.

When the engine is stopped, the spring returns the flyweight lever and control pin assembly to the compression release position ready for the next start.

Camshaft

Inspection and Service

Check the lobes of the camshaft for wear or damage. See Section 1 for minimum lift specifications. Inspect the cam gear for badly worn, chipped or missing teeth. Replacement of the camshaft will be necessary if any of these conditions exist.

Crankshaft

Inspection and Service

Inspect the gear teeth of the crankshaft. If the teeth are badly worn, chipped, or some are missing, replacement of the crankshaft will be necessary.

Section 10
Inspection and Reconditioning

Inspect the crankshaft bearing surfaces for scoring, grooving, etc. Some engines have bearing inserts in the crankshaft bore of the closure plate and/or crankcase. Do not replace bearings unless they show signs of damage or are out of running clearance specifications. If the crankshaft turns easily and noiselessly, and there is no evidence of scoring, grooving, etc., on the races or bearing surfaces, the bearings can be reused.

Inspect the crankshaft keyways. If they are worn or chipped, replacement of the crankshaft will be necessary.

Inspect the crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If the wear limits, as stated in “Specifications and Tolerances” are exceeded, it will be necessary to either replace the crankshaft or regrind the crankpin to **0.25 mm (0.010 in.)** undersize. If reground, a **0.25 mm (0.010 in.)** undersize connecting rod (big end) must then be used to achieve proper running clearance. Measure the crankpin for size, taper, and out-of-round.

NOTE: If the crankpin is reground, visually check to ensure that the fillet blends smoothly with the crankpin surface. See Figure 10-1.

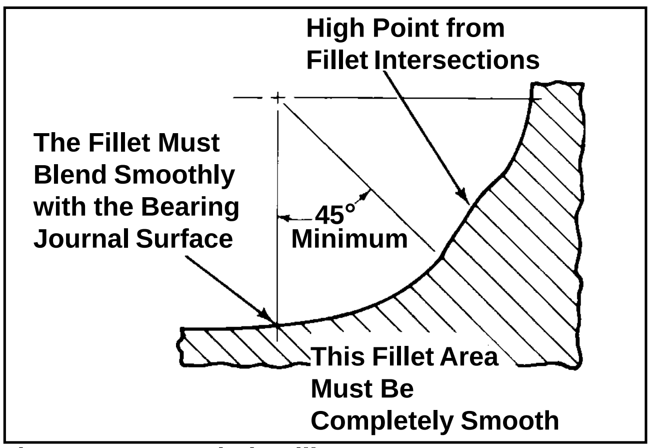


Figure 10-1. Crankpin Fillets.

The connecting rod journal can be ground one size under. When grinding a crankshaft, grinding stone deposits can get caught in the oil passages, which could cause severe engine damage. Removing the crankpin plug when the crankshaft is ground provides easy access for removing any grinding deposits that may collect in the oil passages.

Use the following procedure to remove and replace the plug.

Procedure to Remove Crankshaft Plug:
1. Drill a 3/16" hole through the plug in the crankshaft.

2. Thread a 3/4" or 1" long self-tapping screw with a flat washer into the drilled hole. The flat washer must be large enough to seat against the shoulder of the plug bore. See Figure 10-2.

3. Tighten the self-tapping screw until it draws the plug out of the crankshaft.

Procedure to Install New Plug:
1. Use a single cylinder camshaft pin, Kohler Part No. **47 380 09-S** as a driver and tap the plug into the plug bore until it seats at the bottom of the bore. Make sure the plug is tapped in evenly to prevent leakage.

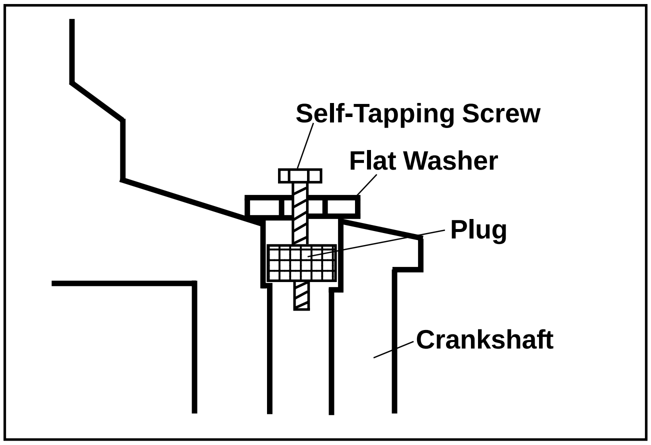


Figure 10-2. Removing Crankpin Plug.

Crankcase

Inspection and Service
Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

Inspect the main bearing (if so equipped) for wear or damage (refer to Section 1, “Specifications, Tolerances, and Special Torque Values”). Replace the crankcase using a miniblock or short block as required.

Check the cylinder bore wall for scoring. In severe cases, unburned fuel can cause scuffing and scoring of the cylinder wall. It washes the necessary lubricating oils off the piston and cylinder wall. As raw fuel seeps down the cylinder wall, the piston rings make metal to metal contact with the wall. Scoring of the cylinder wall can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

If the cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer to determine the amount of wear (refer to the “Specifications, Tolerances, and Special Torque Values”, in Section 1), then select the nearest suitable oversize of either **0.25 mm (0.010 in.)** or **0.50 mm (0.020 in.)**. Resizing to one of these oversizes will allow usage of the available oversize piston and ring assemblies. Initially, resize using a boring bar, then use the following procedures for honing the cylinder.

NOTE: Some CH25-26 engines feature POWER-BORE™ cylinders a special pantented nickel-silicone plating process for increased power, superior oil control, reduced exhaust emission, and virtually permanent cylinder life. POWER-BORE™ cylinders cannot be resized or honed as described in the following procedure. If a plated cylinder bore is damaged or out of specification, use a new miniblock or short block to repair the engine. Use the following procedure for crankcases with a cast iron sleeve.

Honing

While most commercially available cylinder hones can be used with either portable drills or drill presses, the use of a low speed drill press is preferred as it facilitates more accurate alignment of the bore in relation to the crankshaft crossbore. Honing is best accomplished at a drill speed of about **250 RPM** and **60 strokes** per minute. After installing coarse stones in hone, proceed as follows:

1. Lower hone into bore and after centering, adjust so the stones are in contact with the cylinder wall. Use of a commercial cutting-cooling agent is recommended.

2. With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move the hone up and down while resizing to prevent the formation of cutting ridges. Check the size frequently.

NOTE: Kohler pistons are custom-machined to exacting tolerances. When oversizing a cylinder, it should be machined exactly **0.25 mm (0.010 in.)** or **0.50 mm (0.020 in.)** over the new diameter (Section 1). The corresponding oversize Kohler replacement piston will then fit correctly.

3. When the bore is within **0.064 mm (0.0025 in.)** of the desired size, remove the coarse stones and replace them with burnishing stones. Continue with the burnishing stones until the bore is within **0.013 mm (0.0005 in.)** of the desired size and then use finish stones (220-280 grit) and polish the bore to its final size. A crosshatch should be observed if honing is done correctly. The crosshatch should intersect at approximately 23°-33° off the horizontal. Too flat an angle could cause the rings to skip and wear excessively, and too steep an angle will result in high oil consumption. See Figure 10-3.

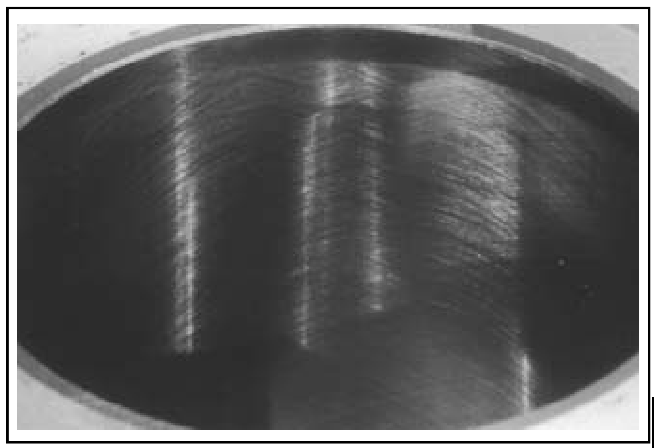


Figure 10-3. Cylinder Bore Crosshatch after Honing.

4. After resizing, check the bore for roundness, taper, and size. Use an inside micrometer, telescoping gauge, or bore gauge to take measurements. The measurements should be taken at three locations in the cylinder – at the top, middle, and bottom. Two measurements should be taken (perpendicular to each other) at each of the three locations.

Clean Cylinder Bore After Honing

Proper cleaning of the cylinder walls following boring and/or honing is very critical to a successful overhaul. Machining grit left in the cylinder bore can destroy an engine in less than one hour of operation after a rebuild.

The final cleaning operation should always be a thorough scrubbing with a brush and hot, soapy water. Use a strong detergent that is capable of breaking down the machining oil while maintaining a good level of suds. If the suds break down during cleaning, discard the dirty water and start again with more hot water and detergent. Following the scrubbing, rinse the cylinder with very hot, clear water, dry it completely, and apply a light coating of engine oil to prevent rusting.

Measuring Piston-to-Bore Clearance

Before installing the piston into the cylinder bore, it is necessary that the clearance be accurately checked. This step is often overlooked, and if the clearances are not within specifications, engine failure will usually result.

NOTE: Do not use a feeler gauge to measure piston-to-bore clearance – it will yield inaccurate measurements. Always use a micrometer.

Use the following procedure to accurately measure the piston-to-bore clearance:

1. Use a micrometer and measure the diameter of the piston **6 mm (0.24 in.)** above the bottom of the piston skirt and perpendicular to the piston pin. See Figure 10-4.

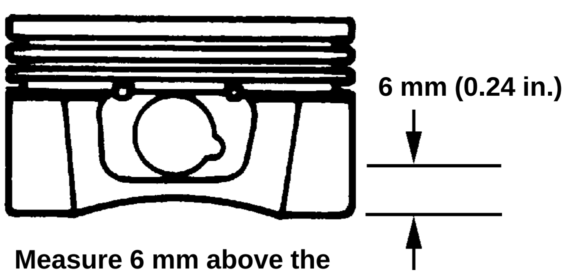


Figure 10-4. Measuring Piston Diameter.

2. Use an inside micrometer, telescoping gauge, or bore gauge and measure the cylinder bore. Take the measurement approximately **63.5 mm (2.5 in.)** below the top of the bore and perpendicular to the piston pin.

3. Piston-to-bore clearance is the difference between the bore diameter and the piston diameter (step 2 minus step 1).

Flywheel

Inspection

Inspect the flywheel for cracks and the flywheel keyway for damage. Replace the flywheel if it is cracked. Replace the flywheel, the crankshaft, and the key if flywheel key is sheared or the keyway is damaged.

Inspect the ring gear for cracks or damage. Kohler does not provide the ring gear as a serviceable part. Replace the flywheel if the ring gear is damaged.

Cylinder Head and Valves

Inspection and Service

After cleaning, check the flatness of the cylinder head and the corresponding top surface of the crankcase, using a surface plate or piece of glass and feeler gauge as shown in Figure 10-5. The maximum allowable out of flatness is **0.076 mm (0.003 in.)**.

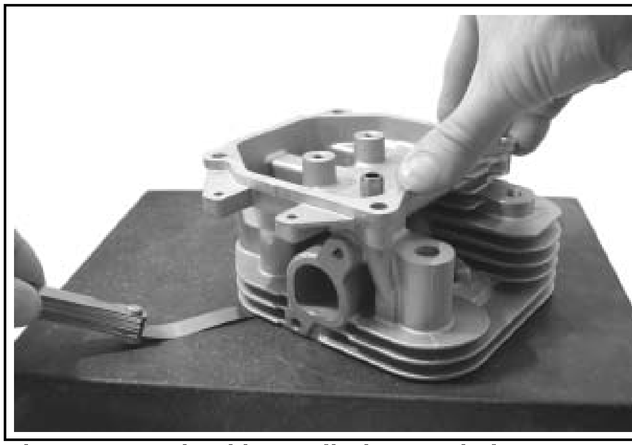
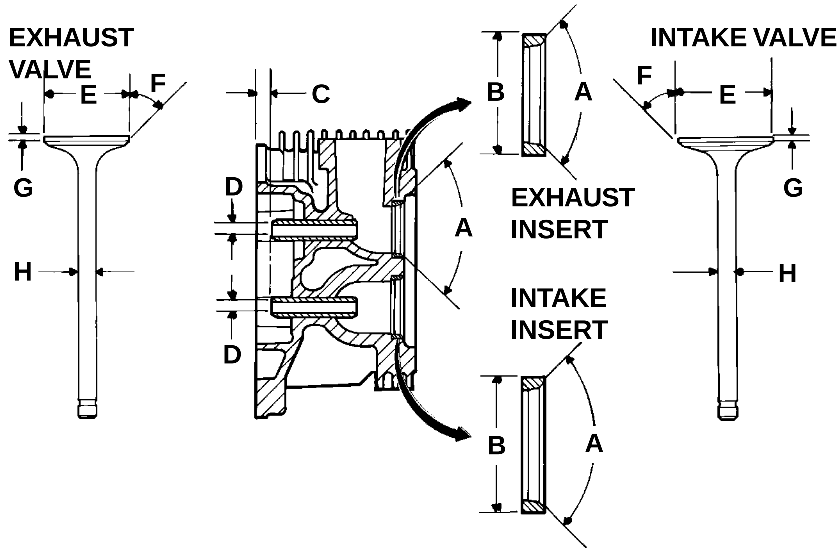


Figure 10-5. Checking Cylinder Head Flatness.

Carefully inspect the valve mechanism parts. Inspect the valve springs and related hardware for excessive wear or distortion. Check the valves and valve seat area or inserts for evidence of deep pitting, cracks, or distortion. Check clearance of the valve stems in the guides. See Figure 10-6 for valve details and specifications.



	Dimension	Intake	Exhaust
A	Seat Angle	89°	89°
B	Insert O.D.	36.987/37.013 mm (1.4562/1.4572 in.)	32.987/33.013 mm (1.2987/1.2997 in.)
C	Guide Depth	4 mm (0.1575 in.)	6.5 mm (0.2559 in.)
D	Guide I.D.	7.038/7.058 mm (0.2771/0.2779 in.)	7.038/7.058 mm (0.2771/0.2779 in.)
E	Valve Head Diameter	33.37/33.63 mm (1.3138/1.3240 in.)	29.37/29.63 mm (1.1563/1.1665 in.)
F	Valve Face Angle	45°	45°
G	Valve Margin (Min.)	1.5 mm (0.0591 in.)	1.5 mm (0.0591 in.)
H	Valve Stem Diameter	6.982/7.000 mm (0.2749/0.2756 in.)	6.970/6.988 mm (0.2744/0.2751 in.)

Figure 10-6. Valve Details.

Hard starting or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Although these symptoms could also be attributed to worn rings, remove and check the valves first. After removal, clean the valve heads, faces, and stems with a power wire brush.

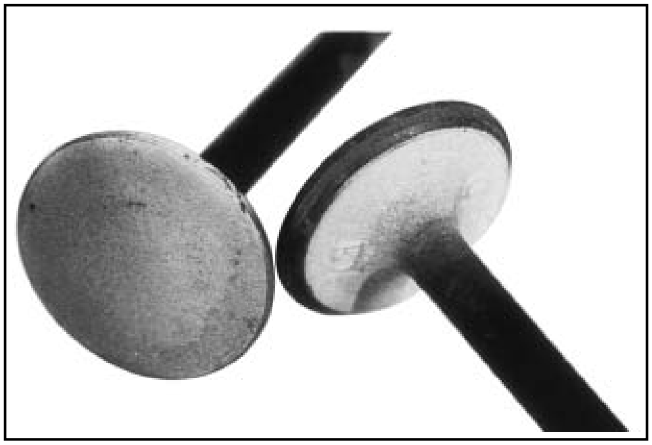
Then, carefully inspect each valve for defects such as a warped head, excessive corrosion, or a worn stem end. Replace valves found to be in bad condition. A normal valve and valves in bad condition are shown in the accompanying illustrations.

Normal: Even after long hours of operation a valve can be reconditioned and reused if the face and margin are in good shape. If a valve is worn to where the margin is less than 1/32" do not reuse it. The valve shown was in operation for almost 1000 hours under controlled test conditions.

Leakage: A poor grind on face or seat of valve will allow leakage resulting in a burned valve on one side only.

Bad Condition: The valve depicted here should be replaced. Note the warped head; margin damaged and too narrow. These conditions could be attributed to excessive hours or a combination of poor operating conditions.

Coking: Coking is normal on intake valves and is not harmful. If the seat is good, the valve could be reused after cleaning.



Excessive Combustion Temperatures: The white deposits seen here indicate very high combustion temperatures, usually due to a lean fuel mixture.

Stem Corrosion: Moisture in fuel or from condensation are the most common causes of valve stem corrosion. Condensation occurs from improper preservation during storage and when engine is repeatedly stopped before it has a chance to reach normal operating temperatures. Replace corroded valves.

Gum: Gum deposits usually result from using stale gasoline. Gum is a prevalent cause of valve sticking. The cure is to ream the valve guides and clean or replace the valves, depending on their condition.

Overheating: An exhaust valve subject to overheating will have a dark discoloration in the area above the valve guide. Worn guides and faulty valve springs may cause this condition. Also check for clogged air intake, and blocked fins when this condition is noted.

Valve Guides
If a valve guide is worn beyond specifications, it will not guide the valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide-to-valve stem clearance, thoroughly clean the valve guide and, using a split-ball gauge, measure the inside diameter of the guide. Then, using an outside micrometer, measure the diameter of the valve stem at several points on the stem where it moves in the valve guide. Use the largest stem diameter to calculate the clearance by subtracting the stem diameter from the guide diameter. If the intake clearance exceeds **0.038/0.076 mm (0.0015/0.003 in.)** or the exhaust clearance exceeds **0.050/0.088 mm (0.0020/0.0035 in.)**, determine whether the valve stem or guide is responsible for the excessive clearance.

The maximum (I.D.) wear on the intake valve guide is **7.134 mm (0.2809 in.)** while **7.159 mm (0.2819 in.)** is the maximum allowed on the exhaust guide. The guides are not removable but can be reamed **0.25 mm (0.010 in.)** oversize with **SPX Tool No. KO1026**. Valves with 0.25 mm oversize stems must then be used.

If the guides are within limits but the valve stems are worn beyond limits, install new valves.

Valve Seat Inserts
Hardened steel alloy intake and exhaust valve seat inserts are press fitted into the cylinder head. The inserts are not replaceable but can be reconditioned if not too badly pitted or distorted. If cracked or badly warped, the cylinder head should be replaced.

Recondition the valve seat inserts following the instructions provided with the valve seat cutter being used. A typical cutter is shown in Figure 10-7. The final cut should be made with an 89° cutter as specified for the valve seat angle in Figure 10-6. Cutting the proper 45° valve face angle as specified in Figure 10-6, and the proper valve seat angle (44.5°, half of the full 89° angle), will achieve the desired 0.5° (1.0° full cut) interference angle where the maximum pressure occurs on the outside diameters of the valve face and seat.

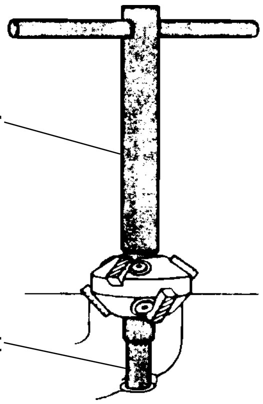


Figure 10-7. Typical Valve Seat Cutter.

Lapping Valves
Reground or new valves must be lapped in, to provide proper fit. Use a hand valve grinder with a suction cup for final lapping. Lightly coat the valve face with a “fine” grade of grinding compound, then rotate the valve on its seat with the grinder. Continue grinding until a smooth surface is obtained on the seat and on the valve face. Thoroughly clean the cylinder head in soap and hot water to remove all traces of grinding compound. After drying the cylinder head, apply a light coating of **SAE 10** oil to prevent rusting.

Intake Valve Stem Seal
These engines use valve stem seals on the intake valves. Always use a new seal when the valves are removed from the cylinder head. The seals should also be replaced if deteriorated or damaged in any way. **Never reuse an old seal.**

Pistons and Rings

Inspection
Scuffing and scoring of pistons and cylinder walls occurs when internal engine temperatures approach the welding point of the piston. Temperatures high enough to do this are created by friction, which is usually attributed to improper lubrication and/or overheating of the engine.

Normally, very little wear takes place in the piston boss-piston pin area. If the original piston and connecting rod can be reused after new rings are installed, the original pin can also be reused but new piston pin retainers are required. The piston pin is included as part of the piston assembly – if the pin boss in the piston or the pin are worn or damaged, a new piston assembly is required.

Ring failure is usually indicated by excessive oil consumption and blue exhaust smoke. When rings fail, oil is allowed to enter the combustion chamber where it is burned along with the fuel. High oil consumption can also occur when the piston ring end gap is incorrect because the ring cannot properly conform to the cylinder wall under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring usually takes on a shiny or bright appearance.

Scratches on rings and pistons are caused by abrasive material such as carbon, dirt, or pieces of hard metal.

Detonation damage occurs when a portion of the fuel charge ignites spontaneously from heat and pressure shortly after ignition. This creates two flame fronts which meet and explode to create extreme hammering pressures on a specific area of the piston. Detonation generally occurs from using low octane fuels.

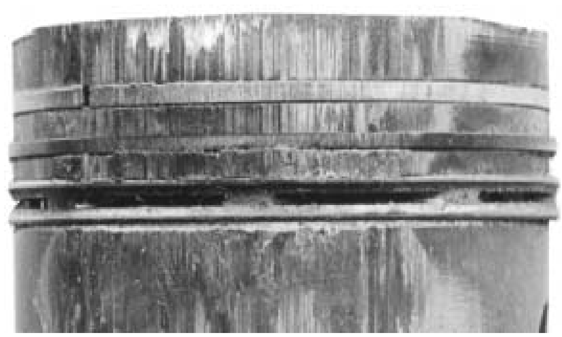
Preignition or ignition of the fuel charge before the timed spark can cause damage similar to detonation. Preignition damage is often more severe than detonation damage. Preignition is caused by a hot spot in the combustion chamber from sources such as glowing carbon deposits, blocked cooling fins, an improperly seated valve, or wrong spark plug(s).

See Figure 10-8 for some common types of piston and ring damage.

Stuck, Broken Rings

Abrasive Scratched Rings

Overheated or Deteriorated Oil



Scored Piston and Rings

Figure 10-8. Common Types of Piston Damage.

Section 10
Inspection and Reconditioning

Replacement pistons are available in STD bore size, and in 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize. Replacement pistons include new piston ring sets and new piston pins.

Replacement ring sets are also available separately for STD, 0.25 mm (0.010 in.), and 0.50 mm (0.020 in.) oversize pistons. Always use new piston rings when installing pistons. Never use old rings.

Some important points to remember when servicing piston rings:

1. The cylinder bore must be deglazed before service ring sets are used.

2. If the cylinder bore does not need reboring and if the old piston is within wear limits and free of score or scuff marks, the old piston may be reused.

3. Remove the old rings and clean up the grooves. **Never reuse old rings.**

4. Before installing the new rings on the piston, place the top two rings, each in turn, in its running area in the cylinder bore and check the end gap. (See Figure 10-9.) Compare the ring gap to the specifications listed in Section 1.

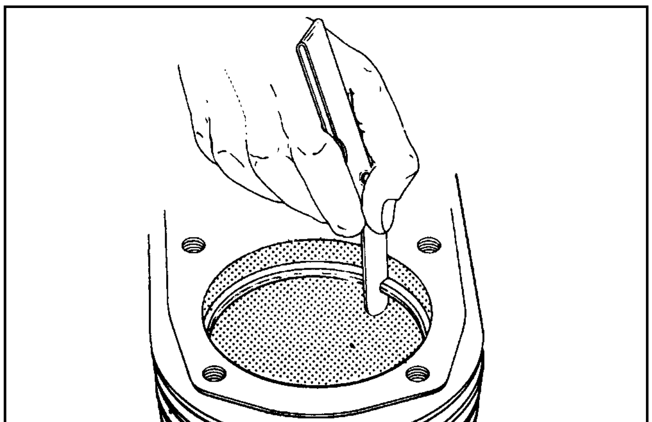


Figure 10-9. Measuring Piston Ring End Gap.

5. After installing the new compression (top and middle) rings on the piston, check the piston-to-ring side clearance. Compare the clearance to specifications listed in Section 1. If the side clearance is greater than specified, a new piston **must** be used. Refer to Figure 10-10.

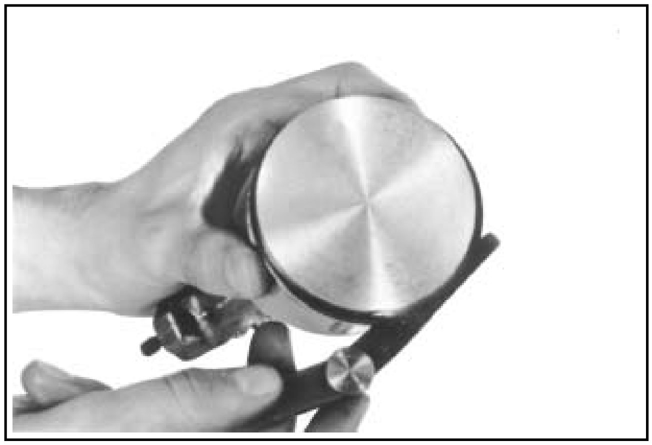


Figure 10-10. Measuring Piston Ring Side Clearance.

Install New Piston Rings
To install new piston rings, proceed as follows:

NOTE: Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use a piston ring expander to install rings (see Figure 10-11). Install the bottom (oil control) ring first and the top compression ring last. Refer to Figure 10-12.

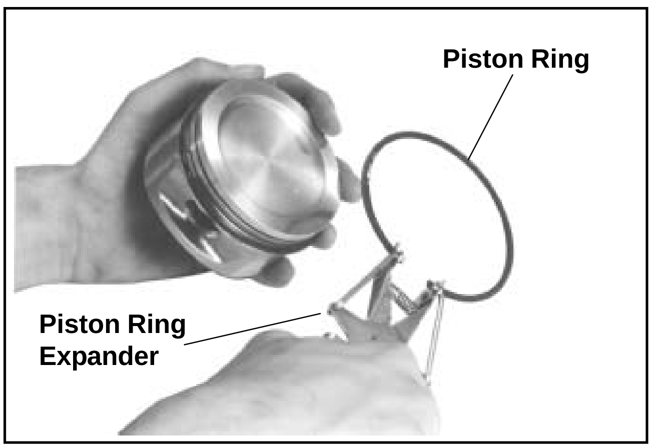


Figure 10-11. Installing Piston Rings.

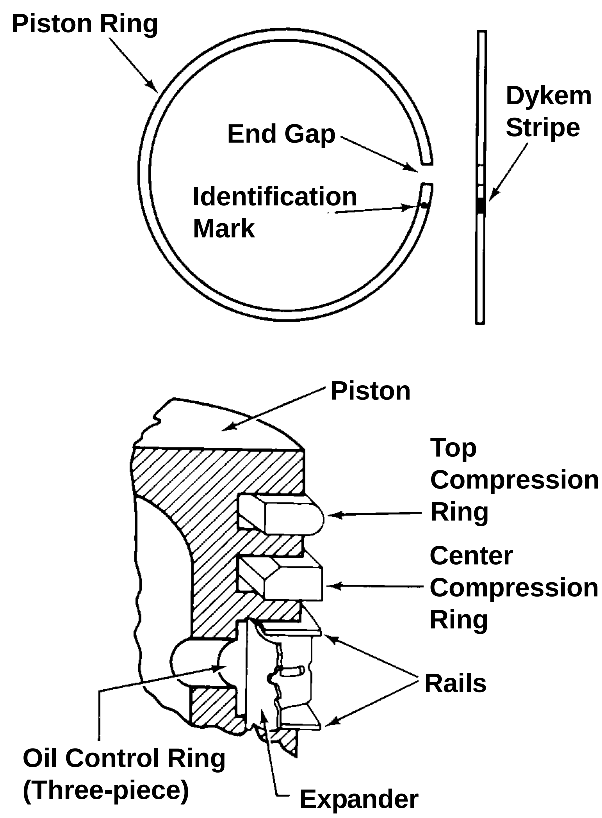


Figure 10-12. Piston Ring Installation.

1. Oil Control Ring (Bottom Groove): Install the expander and then the rails. Make sure the ends of expander are not overlapped.

2. Middle Compression Ring (Center Groove): Install the center ring using a piston ring installation tool. Make sure the “identification” mark is up or the dykem stripe (if contained) is to the left of the end gap.

3. Top Compression Ring (Top Groove): Install the top ring using a piston ring expender. Make sure the “identification” mark is up or the dykem stripe (if contained), to the left of the end gap.

Connecting Rods

Offset, stepped-cap connecting rods are used in all these engines.

Inspection and Service

Check the bearing area (big end) for excessive wear, score marks, running and side clearances (refer to Section 1, “Specifications, Tolerances, and Special Torque Values”). Replace the rod and cap if scored or excessively worn.

Service replacement connecting rods are available in STD crankpin size and **0.25 mm (0.010 in.)** undersize. The **0.25 mm (0.010 in.)** undersized rod can be identified by the drilled hole located in the lower end of the rod shank. Always refer to the appropriate parts information to ensure that correct replacements are used.

Hydraulic Lifters

Inspection

Check the base surface of the hydraulic lifters for wear or damage. If the lifters need to be replaced, apply a liberal coating of Kohler lubricant **25 357 14-S** to the base of each new lifter before it is installed.

“Bleeding” the Lifters

To prevent a possible bent push rod or broken rocker arm, it is important to “bleed” any excess oil out of the lifters before they are installed.

1. Cut a 50-75 mm (2-3 in.) piece from the end of an old push rod and chuck it in a drill press.

2. Lay a rag or shop towel on the table of the drill press and place the lifter, open end up, on the towel.

3. Lower the chucked push rod until it contacts the plunger in the lifter. Slowly “pump” the plunger two or three times to force the oil out of the feed hole in the side of the lifter.

Closure Plate Assembly

Inspection

Inspect the oil seal in the closure plate and remove it if it is worn or damaged. Refer to ‘‘Install Closure Plate Oil Seal’’ in Section 11 for new oil seal installation.

Inspect the main bearing surface for wear or damage (refer to Section 1, “Specifications, Tolerances, and Special Torque Values”). Replace the closure plate assembly if required.

Governor Gear Assembly

Inspection

Inspect the governor gear teeth. Replace the gear if it is worn, chipped, or if any teeth are missing. Inspect the governor weights. They should move freely in the governor gear.

Disassembly
The governor gear **must** be replaced once it is removed from the closure plate.

NOTE: The governor gear is held onto the shaft by small molded tabs in the gear. When the gear is removed from the shaft, these tabs are destroyed and the gear must be replaced. Therefore, remove the gear **only** if absolutely necessary.

1. Remove the regulating pin and governor gear assembly. See Figure 10-13.

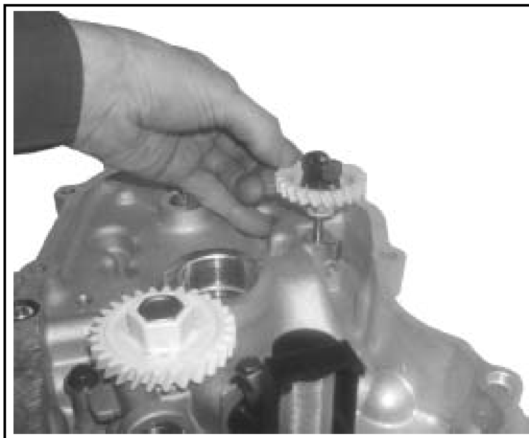


Figure 10-13. Removing Governor Gear.

2. Remove the locking tab thrust washer located under the governor gear assembly.

3. Carefully inspect the governor gear shaft and replace it only if it is damaged. After removing the damaged shaft, press or lightly tap the replacement shaft into the closure plate to the depth shown in Figure 10-14.

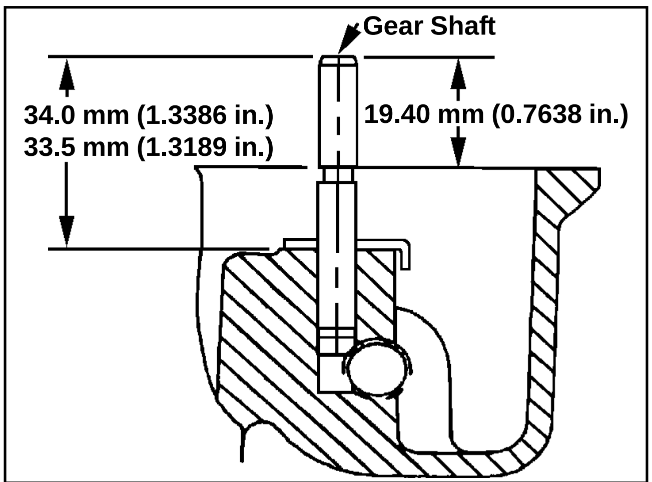


Figure 10-14. Governor Shaft Press Depth.

Reassembly
1. Install the locking tab thrust washer on the governor gear shaft with the tab down.

2. Position the regulating pin within the governor gear/flyweight assembly and slide both onto the governor shaft.

Oil Pump Assembly

Disassembly
1. Remove the two hex. flange screws.

2. Remove the oil pump assembly from the closure plate.

3. Remove the oil pump rotor.

4. Remove the oil pickup by unhooking the locking clip, and pulling it free from the oil pump body.

5. If the relief valve is like that shown in Figure 10-15, drive out the pin to remove the oil pressure relief valve piston and spring. Refer to the following inspection and reassembly procedures.

   If the relief valve is a one-piece style, staked to the oil pump housing (See Figure 10-16) removal should not be attempted, nor is internal servicing possible. If a problem with the relief valve is encountered, the oil pump should be replaced.

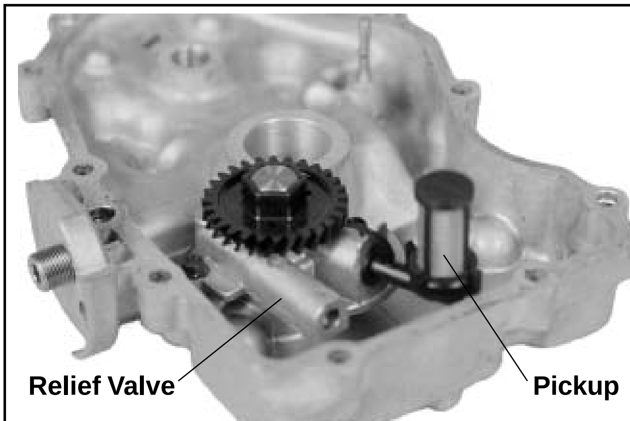


Figure 10-15. Oil Pump, Oil Pickup, and Relief Valve (Original Style).

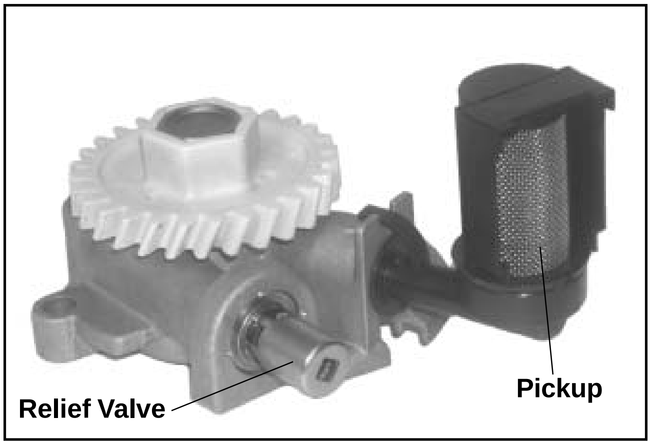


Figure 10-16. Oil Pump, Oil Pickup, and One-Piece Relief Valve (Later Style).

Inspection
Inspect the oil pump housing, gear, and rotors for nicks, burrs, wear, or any visible damage. If any parts are worn or damaged, replace the oil pump.

Inspect the oil pressure relief valve piston. It should be free of nicks or burrs.

Check the spring for wear or distortion. The free length of the spring should be approximately **47.4 mm (1.8 in.)**. Replace the spring if it is distorted or worn. See Figure 10-17.

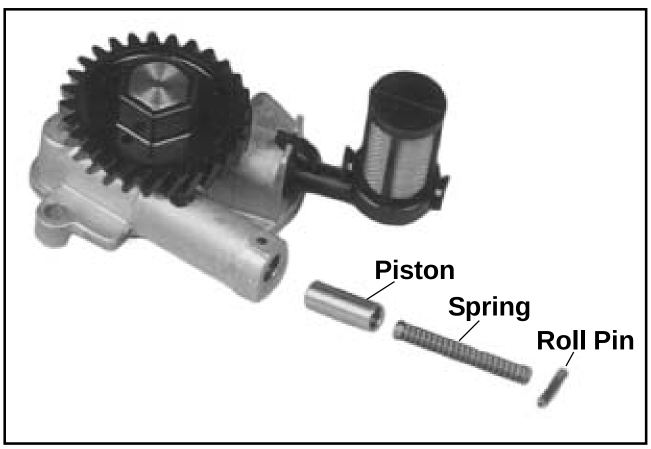


Figure 10-17. Oil Pressure Relief Valve Piston and Spring.

Reassembly
1. Install the pressure relief valve piston and spring.

2. Install the oil pickup to the oil pump body. Lubricate the O-Ring with oil and make sure it remains in the groove as the pickup is being installed.

3. Install the rotor.

4. Install the oil pump body to the closure plate and secure with the two hex. flange screws. Torque the hex. flange screws as follows:

   First Time Installation: 10.7 N·m (95 in. lb.)
   All Reinstallations: 6.7 N·m (60 in. lb.)

5. After torquing, rotate the gear and check for freedom of movement. Make sure there is no binding. If binding occurs, loosen the screws, reposition the pump, retorque the hex flange screws and recheck the movement.

Governor Cross Shaft Oil Seal
If the governor cross shaft seal is damaged and/or leaks, replace it using the following procedure.

Remove the oil seal from the crankcase and replace it with a new one. Install the new seal to the depth shown in Figure 10-18 using a seal installer.

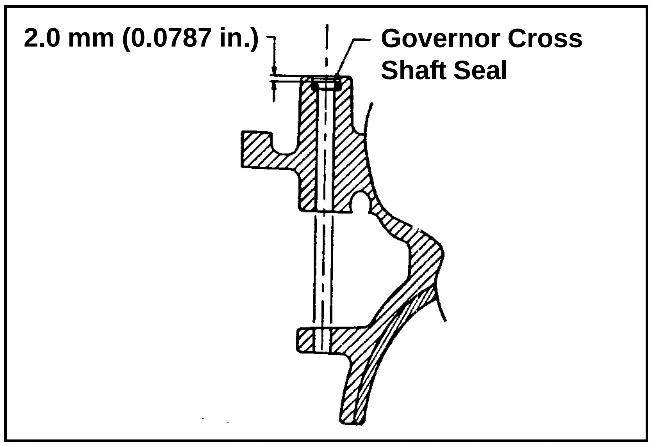


Figure 10-18. Installing Cross Shaft Oil Seal.

10

Section 11
Reassembly

General

NOTE: Make sure the engine is assembled using all specified torque values, tightening sequences and clearances. Failure to observe specifications could cause severe engine wear or damage. Always use new gaskets.

Make sure all traces of any cleaner are removed before the engine is assembled and placed into operation. Even small amounts of these cleaners can quickly break down the lubricating properties of engine oil.

Check the closure plate, crankcase, cylinder heads, and valve covers to be certain that all of the old RTV has been removed. Use gasket remover, lacquer thinner, or paint remover to remove any remaining traces. Clean the surfaces with isopropyl alcohol, acetone, lacquer thinner, or electrical contact cleaner.

Typical Reassembly Sequence

The following sequence is suggested for complete engine reassembly. This procedure assumes that all components are new or have been reconditioned, and all component subassembly work has been completed. The sequence may vary to accommodate options or special equipment. Detailed procedures follow.

1. Install flywheel end oil seal.
2. Install governor cross shaft.
3. Install crankshaft.
4. Install connecting rods with pistons and rings.
5. Install camshaft.
6. Install closure plate assembly.
7. Install stator and backing plates.
8. Install flywheel.
9. Install fan and grass screen.
10. Install hydraulic lifters.
11. Install cylinder heads.
12. Install ignition modules.
13. Install intake manifold.
14. Install breather cover and inner baffles.
15. Install blower housing and outer baffles.
16. Install electric starter motor.
17. Install fuel pump.
18. Install carburetor.
19. Install external governor controls.
20. Install throttle and choke controls.
21. Install Oil Sentry™.
22. Install control panel (if so equipped).
23. Install valve covers.
24. Install air cleaner assembly (see Section 4).
25. Install muffler.
26. Install oil filter and add oil to crankcase.
27. Connect spark plug leads.

Install Flywheel End Oil Seal

1. Make sure that the seal bore of the crankcase is clean and free of any nicks or burrs. See Figure 11-1.

Figure 11-1. Seal Bore of Crankcase.

2. Apply a light coat of clean engine oil to the outside diameter of the oil seal.

3. Drive the oil seal into the crankcase using a seal driver. Make sure the oil seal is installed straight and true in the bore and that the tool bottoms against the crankcase. See Figure 11-2.

11

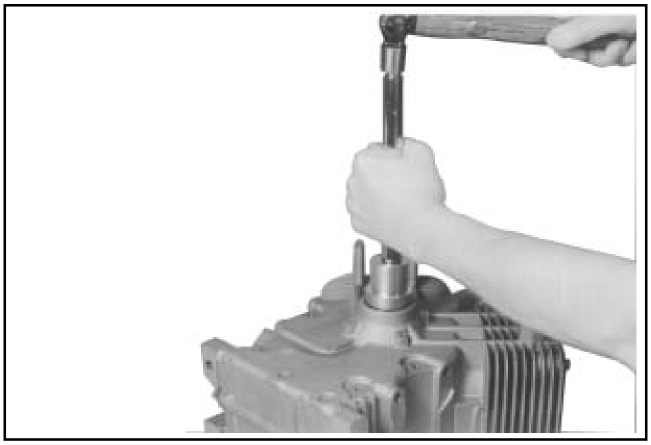


Figure 11-2. Installing Oil Seal.

Install Governor Cross Shaft

1. Lubricate the governor cross shaft bearing surfaces in the crankcase with engine oil.

2. Slide the small lower washer onto the governor cross shaft and install the cross shaft from the inside of the crankcase.

3. **6 mm Governor Shaft:** Install the plain washer and then insert the hitch pin into the smaller, lower hole of the governor cross shaft. See Figures 11-3 and 11-4.

   8 mm Governor Shaft: Install the nylon washer onto the governor cross shaft, then start the push-on retaining ring. Hold the cross shaft up in position, place a 0.50 mm (0.020 in.) feeler gauge on top of the nylon washer, and push the retaining ring down the shaft to secure. Remove the feeler gauge, which will have established the proper end play. See Figures 11-5 and 11-6.

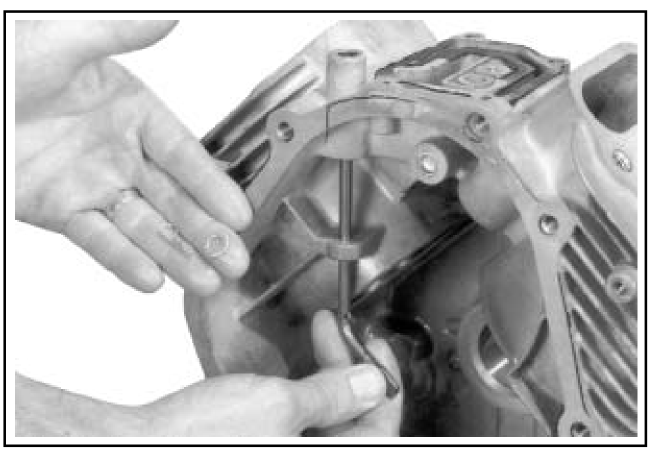


Figure 11-3. Installing 6 mm Governor Cross Shaft.

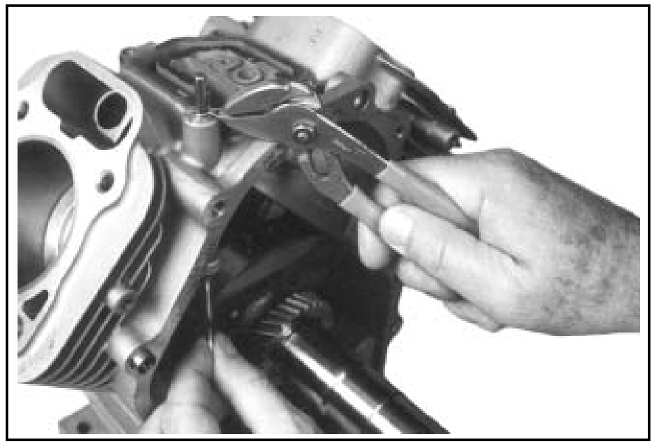


Figure 11-4. Installing Governor Cross Shaft Hitch Pin (6 mm Shaft).

Figure 11-5. Installing 8 mm Governor Cross Shaft.

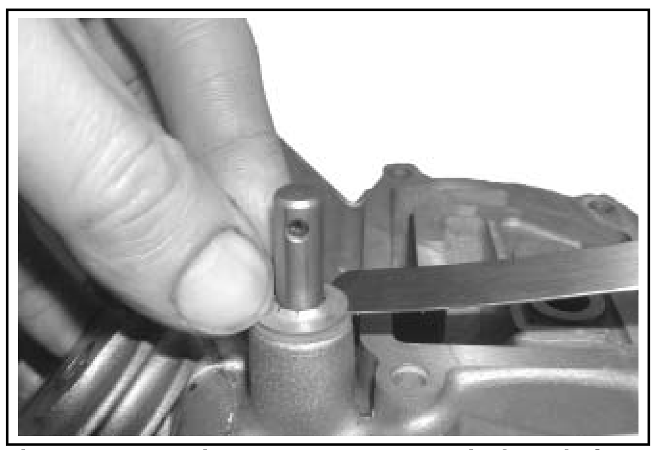


Figure 11-6. Setting Governor Cross Shaft End Play (8 mm Shaft).

Install Crankshaft

1. Carefully slide the flywheel end of the crankshaft through the main bearing in the crankcase. See Figure 11-7.

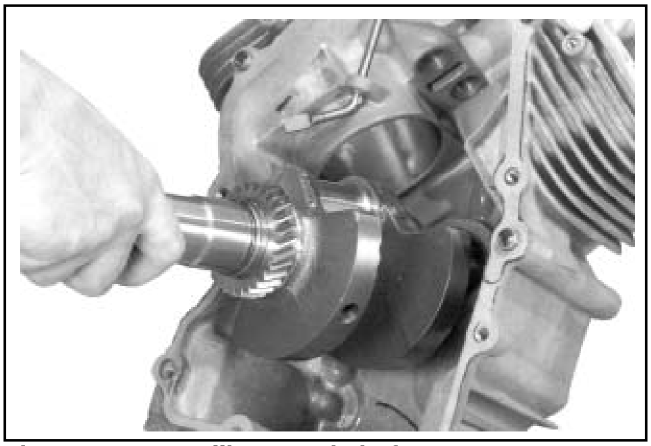


Figure 11-7. Installing Crankshaft.

Install Connecting Rods with Pistons and Rings

NOTE: The cylinders are numbered on the crankcase. Make sure to install the piston, connecting rod and end cap into its appropriate cylinder bore as previously marked at disassembly. **Do not** mix the end caps and connecting rods.

NOTE: Proper orientation of the piston/connecting rod assemblies inside the engine is extremely important. Improper orientation can cause extensive wear or damage. Be certain the pistons and connecting rods are assembled exactly as shown in Figure 11-8.

1. Stagger the piston rings in the grooves until the end gaps are 120° apart. The oil ring rails should also be staggered.

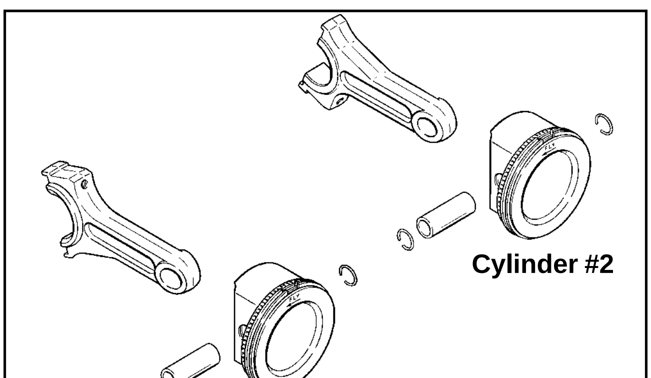


Figure 11-8. Piston, Connecting Rod and End Cap Detail.

2. Lubricate the cylinder bore, piston, and piston rings with engine oil. Compress the rings of the #1 piston using a piston ring compressor.

3. Lubricate the crankshaft journals and connecting rod bearing surfaces with engine oil.

4. Make sure the “Fly” stamping on piston is facing towards the flywheel side of the engine. Use a hammer with a rubber grip and gently tap the piston into the cylinder as shown in Figure 11-9. Be careful that the oil ring rails do not spring free between the bottom of the ring compressor and top of the cylinder.

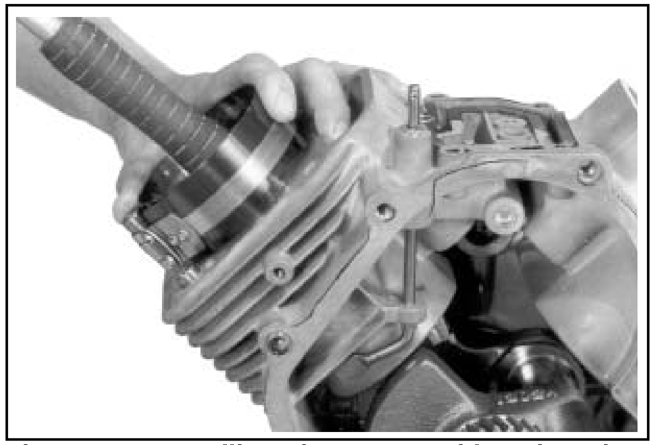


Figure 11-9. Installing Piston Assembly Using Ring Compressor Tool.

5. Install the inner rod cap to the connecting rod using the two hex. flange screws. Three different types of connecting rod bolts have been used and each has a different torque value. If 8 mm straight shank type bolts are used, torque in increments to **22.7 N·m (200 in. lb.)**. If 8 mm step-down bolts are used, torque in increments to **14.7 N·m (130 in. lb.)**. If 6 mm straight shank bolts are used, torque in increments to **11.3 N·m (100 in. lb.)**. Illustrated instructions are provided in the service rod package. See Figures 11-10 and 11-11.

   NOTE: Align the chamfer of the connecting rod with the chamfer of its mating end cap. When installed, the flat faces of the connecting rods should face each other. The faces with the raised rib should be toward the outside.

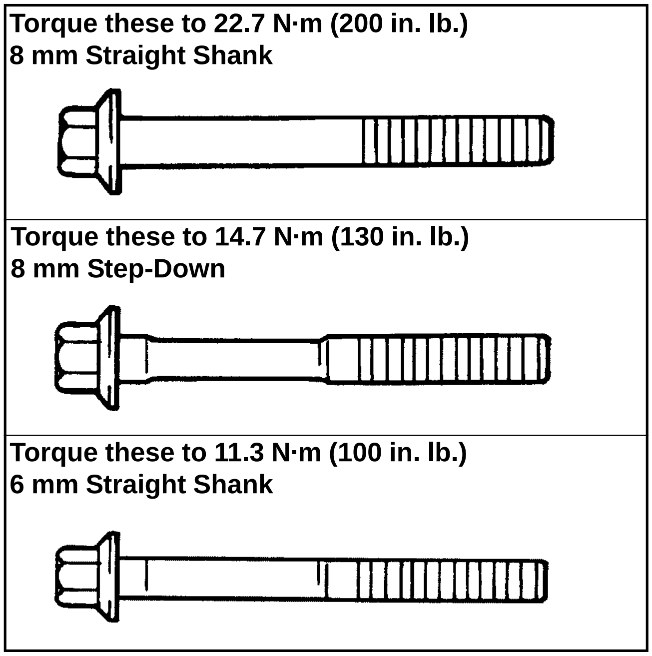


Figure 11-10. Connecting Rod Bolts.

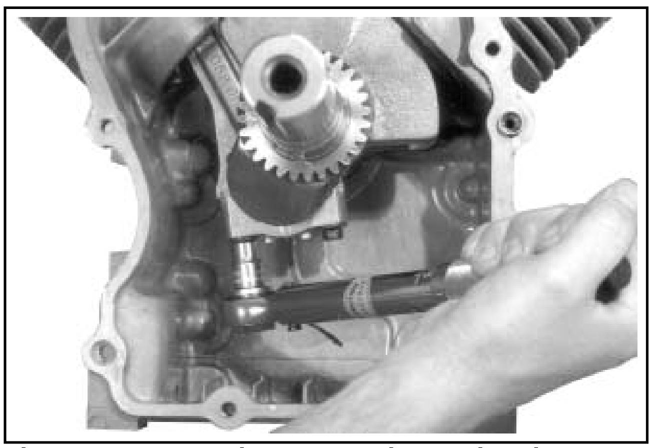


Figure 11-11. Torquing Connecting Rod End Cap.

6. Repeat the above procedure for the other connecting rod and piston assembly.

Install Camshaft

1. Liberally apply camshaft lubricant (Kohler Part No. **25 357 14-S**) to each of the cam lobes. Lubricate the camshaft bearing surfaces of the crankcase and the camshaft with engine oil. See Figure 11-12.

Figure 11-12. Apply Camshaft Lubricant to Cam Lobes.

2. Position the timing mark of the crankshaft gear at the 12 o'clock position.

3. Turn the governor cross shaft clockwise until the lower end of the shaft contacts the cylinder. Make sure the cross shaft remains in this position while installing the camshaft. See Figure 11-13.

4. Slide the camshaft into the bearing surface of the crankcase, positioning the timing mark of the camshaft gear at the 6 o'clock position. Make sure that the camshaft gear and crankshaft gear mesh, with both timing marks aligned. See Figure 11-13.

Figure 11-13. Aligning Crankshaft and Camshaft Timing Marks.

Determining Camshaft End Play

1. Install the shim removed during disassembly onto the camshaft.

2. Position the camshaft end play checking tool on the camshaft. See Figure 11-14.

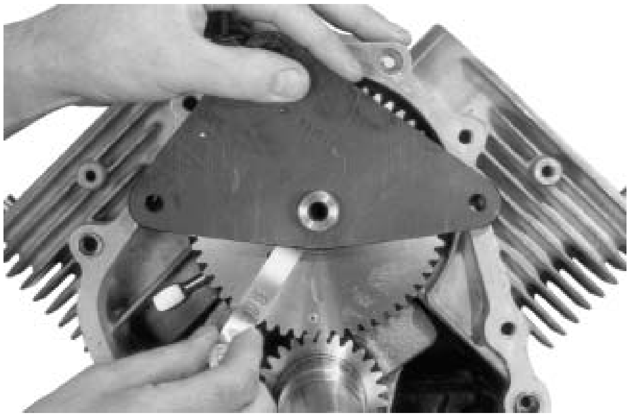


Figure 11-14. Checking Camshaft End Play.

3. Apply pressure on the camshaft end play checking tool (pushing camshaft toward crankshaft). Use a feeler gauge to measure the camshaft end play between the shim spacer and the checking tool. Camshaft end play should be **0.076/0.127 mm (0.003/0.005 in.)**.

4. If the camshaft end play is not within the specified range, remove the checking tool and replace the shim as necessary.

Several color coded shims are available:

White:	0.69215/0.73025 mm (0.02725/0.02875 in.)
Blue:	0.74295/0.78105 mm (0.02925/0.03075 in.)
Red:	0.79375/0.83185 mm (0.03125/0.03275 in.)
Yellow:	0.84455/0.88265 mm (0.03325/0.03475 in.)
Green:	0.89535/0.99345 mm (0.03525/0.03675 in.)
Gray:	0.94615/0.98425 mm (0.03725/0.03875 in.)
Black:	0.99695/1.03505 mm (0.03925/0.04075 in.)

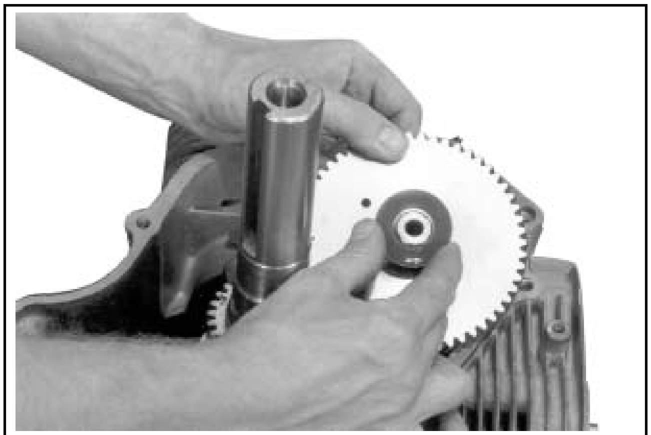


Figure 11-15. Change Shim to Obtain Correct End Play.

5. Reinstall the end play checking tool and recheck the end play.

Oil Pump Assembly

The oil pump is mounted inside the closure plate. If service was required, and the oil pump was removed, refer to the assembly procedures under "Oil Pump Assembly" in Section 10.

Governor Gear Assembly

The governor gear assembly is located inside the closure plate. If service was required, and the governor was removed, refer to the assembly procedures under "Governor Gear Assembly" in Section 10.

Thrust Bearing, Washer and Shim

Some specifications use a needle type thrust bearing, thrust washer and shim spacer to control the end play of the crankshaft. See Figure 11-16. If these items are noted during disassembly, make sure they are reinstalled in the sequence shown in Figure 11-17. A different procedure will have to be followed to check and adjust crankshaft end play on these models.

Figure 11-16. Thrust Bearing, Washer and Shim Used on Some Models.

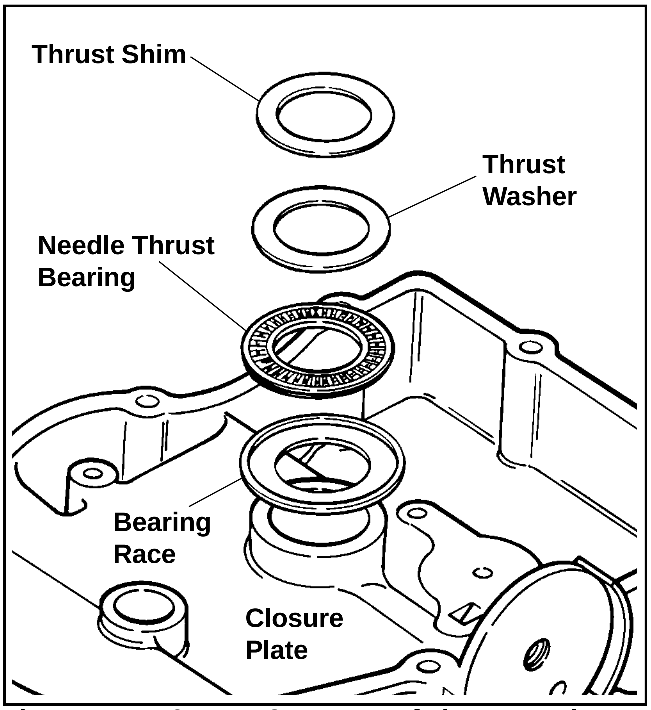


Figure 11-17. Correct Sequence of Thrust Bearing, Washer and Shim in Closure Plate.

The race for the thrust bearing presses loosely into the closure plate. If it is not already installed, push it into the crankshaft bore inside the closure plate. Pack the thrust bearing with heavy grease and stick the bearing into the race. Wipe some grease on the face of the thrust washer and stick it onto the thrust bearing. Wipe some grease on the face of the original shim spacer and stick it onto the thrust washer.

Install the closure plate onto the crankcase **without** applying RTV sealant and secure it with only two or three of the fasteners at this time. Use a dial indicator to check the crankshaft end play. End play should be 0.05/0.50 mm (0.0020/0.0197 in.), except for CH25 engines below Serial No. 2403500008 end play should be 0.050/0.75 mm (0.0020/0.0295 in.). Shim spacers are available in the three color coded thicknesses listed below if adjustment is needed.

Crankshaft End Play Shims

GREEN	0.8366-0.9127 mm (0.8750 mm/0.034 in. Nominal)
YELLOW	1.0652-1.1414 mm (1.1033 mm/0.043 in. Nominal)
RED	1.2938-1.3700 mm (1.3319 mm/0.052 in. Nominal)

Remove the closure plate. If end play requires adjustment, remove the original spacer and install the appropriate size shim spacer in its place. Then follow the procedure under "Install Closure Plate Assembly."

Install Closure Plate Oil Seal

1. Check to make sure that there are no nicks or burrs in the crankshaft bore of the closure plate.

2. Apply a light coat of engine oil to the outside diameter of the oil seal.

3. Drive the oil seal into the closure plate using a seal driver. Make sure the oil seal is installed straight and true in the bore to the depth shown in Figure 11-18.

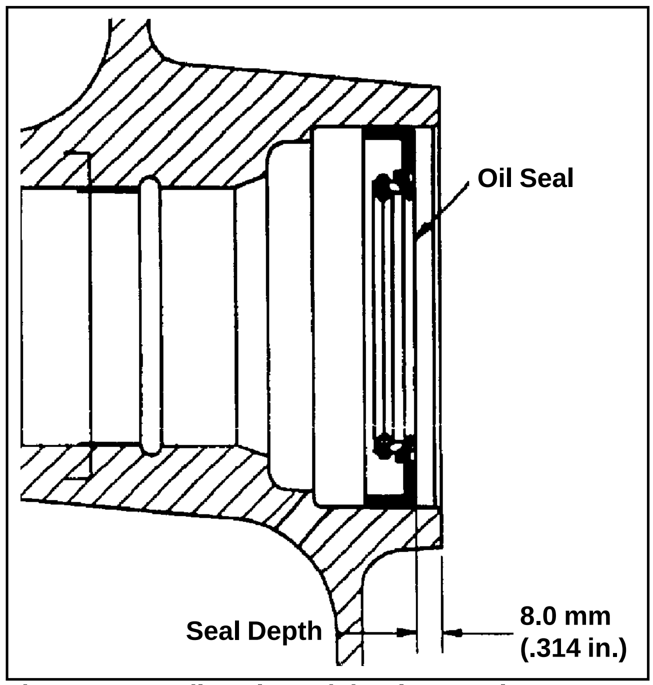


Figure 11-18. Oil Seal Depth in Closure Plate.

Install Closure Plate Assembly

RTV sealant is used as a gasket between the closure plate and the crankcase. Refer to Section 2 for a listing of approved sealants. Always use fresh sealant. Using outdated sealant can result in leakage.

1. Be sure the sealing surfaces have been cleaned and prepared as described at the beginning of Section 10 or in Service Bulletin 252.

2. Check to make sure that there are no nicks or burrs on the sealing surfaces of the closure plate or crankcase.

3. Apply a 1.5 mm (1/16 in.) bead of sealant to the sealing surface of the closure plate. See Figure 11-19 for sealant pattern.

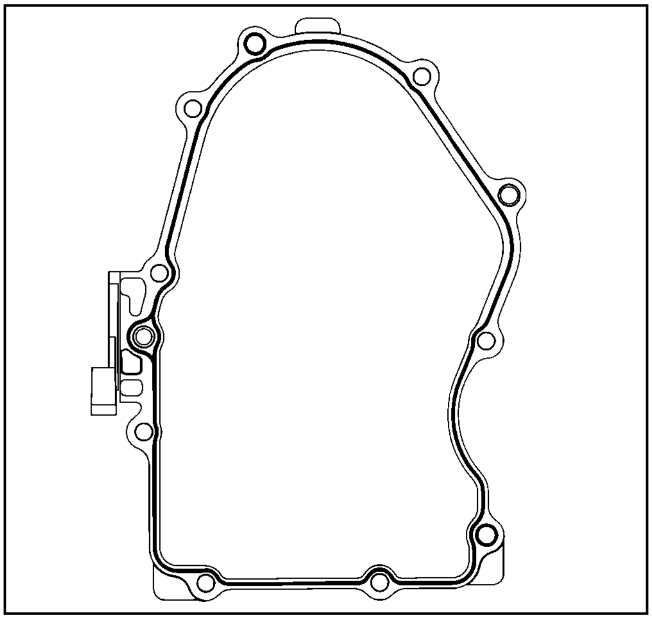


Figure 11-19. Closure Plate Sealant Pattern.

4. Make sure the end of the governor cross shaft is lying against the bottom of cylinder 1 inside the crankcase. See Figure 11-13.

5. Install the closure plate to the crankcase. Carefully seat the camshaft and the crankshaft into their mating bearings. Rotate the crankshaft slightly to help engage the oil pump and governor gear meshes. See Figure 11-20.

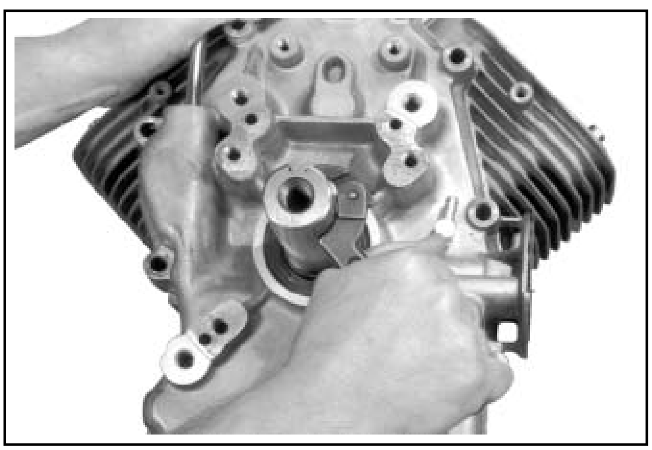


Figure 11-20. Using Spanner Wrench to Turn Crankshaft.

6. Install the ten hex. flange screws securing the closure plate to the crankcase. Torque fasteners in the sequence shown in Figure 11-21 to **24.4 N·m (216 in. lb.)**. On some engines one of the ten mounting screws is plated. The plated screw is typically installed in the #6 hole shown in Figure 11-21.

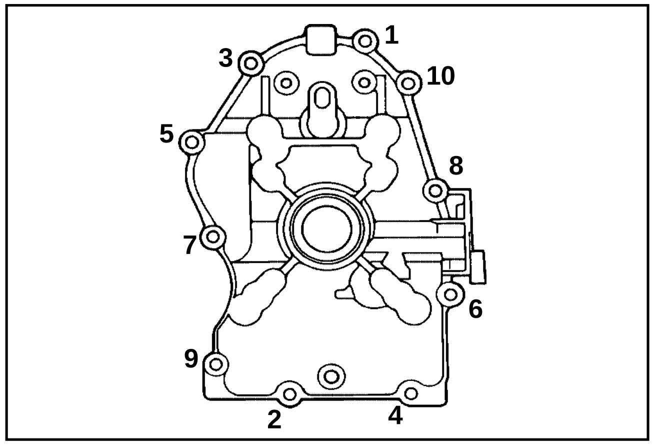


Figure 11-21. Closure Plate Fastener Torque Sequence.

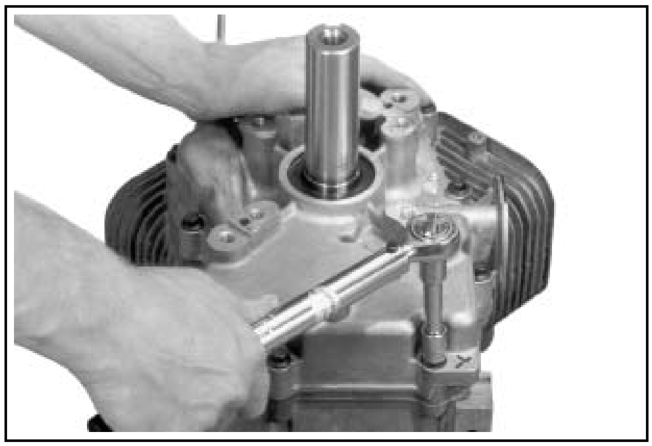


Figure 11-22. Torquing Closure Plate Fasteners.

11

Install Stator and Backing Plates

1. Apply pipe sealant with Teflon® (Loctite® No 59241 or equivalent) to the stator mounting holes.

2. Position the stator aligning the mounting holes so that the leads are at the bottom, towards the crankcase.

3. Install and torque the two hex. flange screws to **6.2 N·m (55 in. lb.)**. See Figure 11-23.

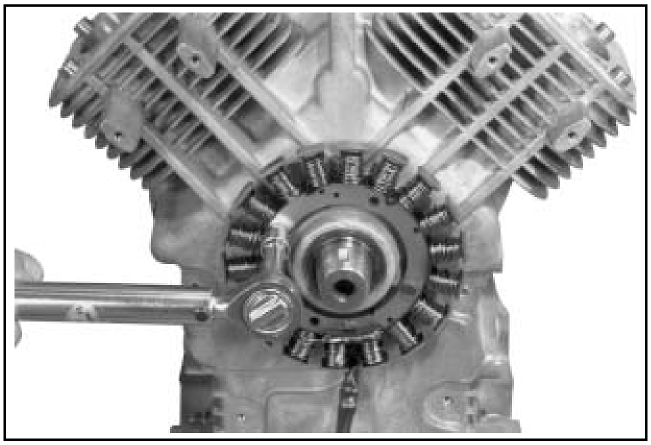


Figure 11-23. Torquing Stator Screws.

4. Route the stator leads in the crankcase channel, then install the backing plates and the stator wire bracket (if used). Secure using the four hex. flange screws. See Figures 11-24 and 11-25. Torque the screws to **7.3 N·m (65 in. lb.)**.

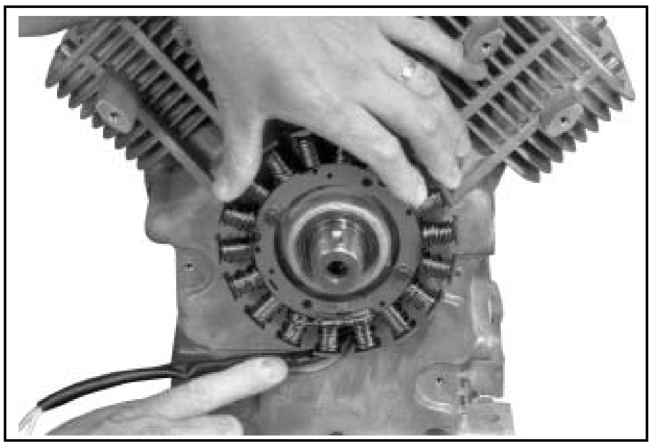


Figure 11-24. Route Stator Leads in Groove.

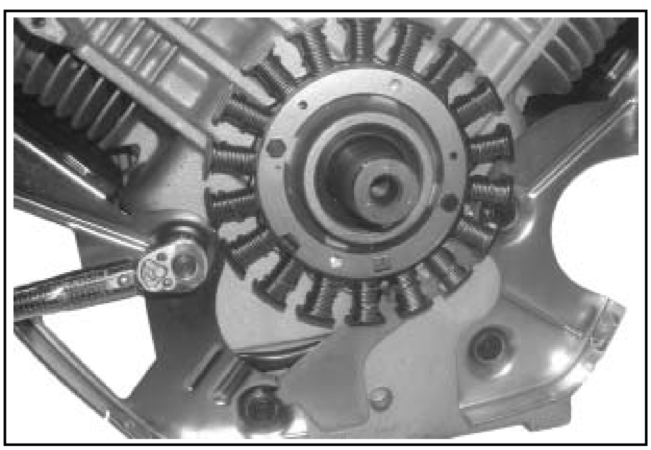


Figure 11-25. Installing Backing Plates and Stator Wire Bracket.

Install Flywheel

WARNING: Damaging Crankshaft and Flywheel Can Cause Personal Injury!

Using improper procedures to install the flywheel can crack or damage the crankshaft and/or flywheel. This not only causes extensive engine damage, but can also cause personal injury, since broken fragments could be thrown from the engine. Always observe and use the following precautions and procedures when installing the flywheel.

NOTE: Before installing the flywheel make sure the crankshaft taper and the flywheel hub are clean, dry, and completely free of any lubricants. The presence of lubricants can cause the flywheel to be over stressed and damaged when the hex. flange screw is torqued to specifications.

Figure 11-26. Clean and Dry Taper of Crankshaft.

Figure 11-27. Clean and Dry Flywheel Hub.

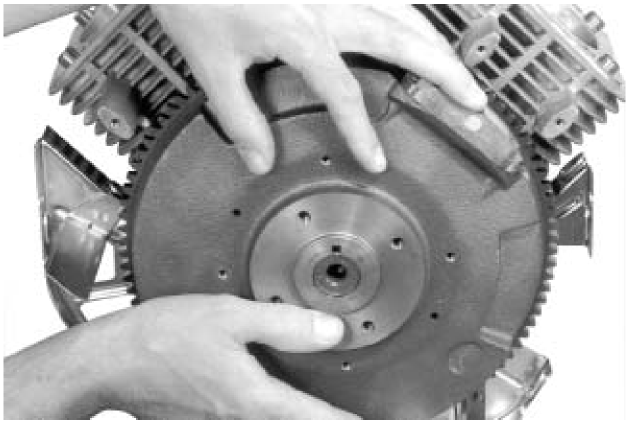


Figure 11-28. Carefully Align Keyway to Key.

NOTE: Make sure the flywheel key is installed properly in the keyway. The flywheel can become cracked or damaged if the key is not properly installed.

1. Install the woodruff key into the keyway of the crankshaft. Make sure that the key is properly seated and parallel with the shaft taper.

2. Install the flywheel onto the crankshaft being careful not to shift the woodruff key. See Figure 11-28.

3. Install the hex. flange screw and washer.

4. Use a flywheel strap wrench or holding tool to hold the flywheel. Torque the hex. flange screw securing the flywheel to the crankshaft to **66.4 N·m (49 ft. lb.)**. See Figure 11-29.

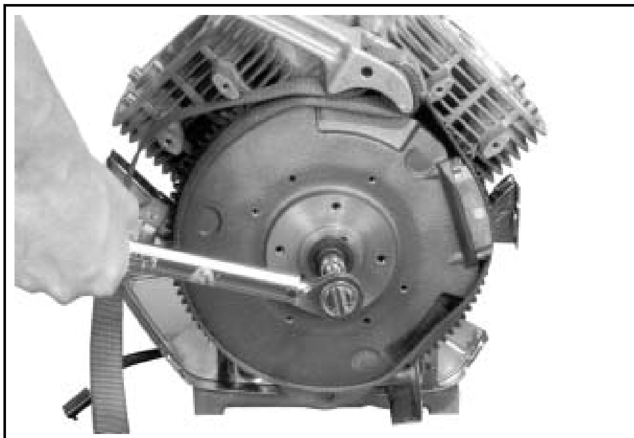


Figure 11-29. Installing and Torquing Flywheel Fastener.

Install Flywheel Fan

1. Install the fan onto the flywheel using the four hex. flange screws.

   NOTE: Position the ears located at rear perimeter of the fan in the recesses of the flywheel. See Figure 11-30.

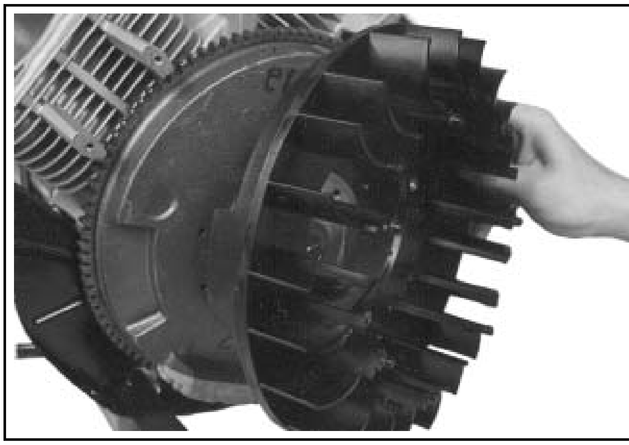


Figure 11-30. Installing Fan on Flywheel.

2. Torque the screws to **9.9 N·m (88 in. lb.)**.

Install Plastic Grass Screen

1. If the engine has a plastic grass screen, snap the screen onto the fan. See Figure 11-31. Due to the possibility of damaging the posts during removal, install the retainers on different posts from which they were removed. Start the retainers by hand, then push them down with a 13 mm (1/2") socket until they lock. If the engine has a metal screen, it will be installed later.

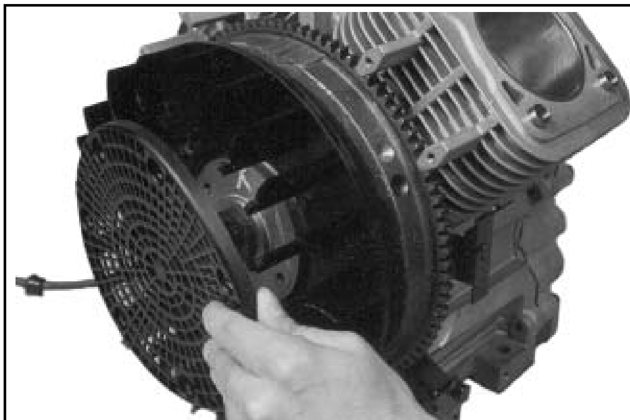


Figure 11-31. Installing Plastic Grass Screen.

Install Supports for the Metal Grass Screen

1. If a metal grass screen is used, with threaded individual supports, install a spacer washer on the external threads. Apply blue Loctite® No. 242 (removable) onto the threads. Install the four supports as shown in Figure 11-32.

Figure 11-32. Installing Supports for Metal Grass Screen.

2. Tighten the supports with a torque wrench to **9.9 N·m (88 in. lb.)**. See Figure 11-33. The grass screen will be installed to the supports after the blower housing is in place.

Figure 11-33. Torquing Supports for Metal Screen (Some Models).

Install Hydraulic Lifters

1. See "Servicing Hydraulic Lifters" in Section 10 for lifter preparation (bleed down) procedures.

2. Apply camshaft lubricant (Kohler Part No. **25 357 14-S**) to the bottom surface of each lifter. See Figure 11-34. Lubricate the hydraulic lifters and the lifter bores in the crankcase with engine oil.

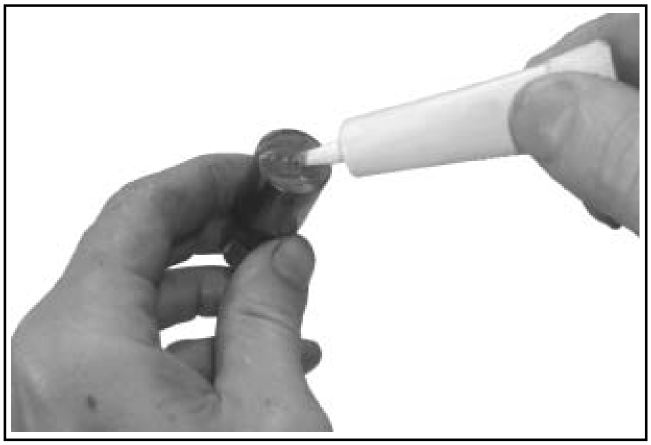


Figure 11-34. Applying Camshaft Lubricant to Bottom of Lifters.

3. Note the mark or tag identifying the hydraulic lifters as either intake or exhaust and cylinder 1 or cylinder 2. Install the hydraulic lifters into their appropriate location in the crankcase. **Do not** use a magnet. See Figure 11-35.

   NOTE: Hydraulic lifters should always be installed in the same position as before disassembly. The exhaust lifters are located on the output shaft side of the engine while the intake lifters are located on the fan side of the engine. The cylinder numbers are embossed on the top of the crankcase and each cylinder head. See Figure 11-36.

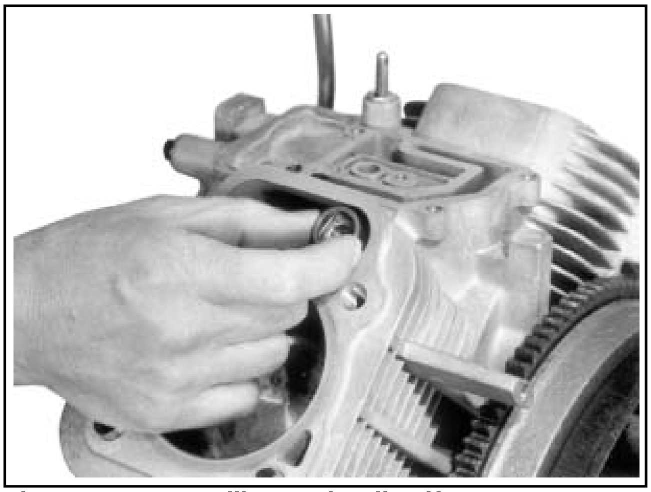


Figure 11-35. Installing Hydraulic Lifters.

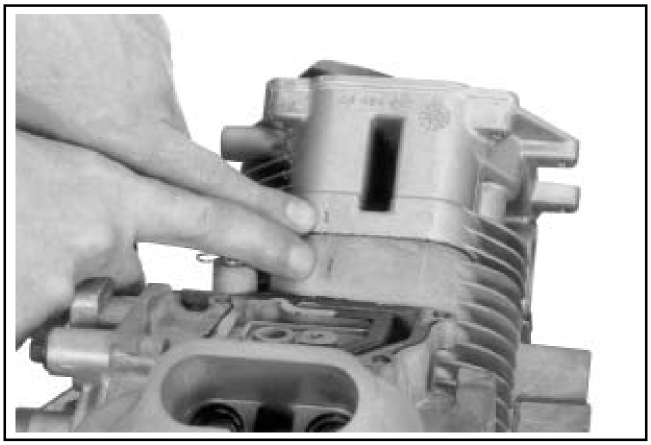


Figure 11-36. Match Numbers on Cylinder Barrel and Head.

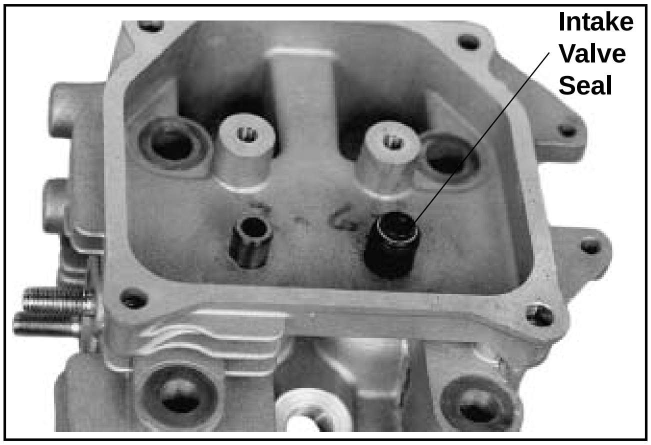


Figure 11-37. Intake Valve Seal Location.

Valve Stem Seals

These engines use valve stem seals on the intake valves and occasionally on the exhaust valves. Always use a new seal whenever the valve is removed or if the seal is deteriorated or damaged in any way. Never reuse an old seal. Figure 11-37.

Assemble Cylinder Heads

Prior to installation, lubricate all components with engine oil, paying particular attention to the lip of the valve stem seal, valve stems and valve guides. Install the following items in the order listed below using a valve spring compressor. See Figures 11-38 and 11-39.

- Intake and exhaust valves
- Valve spring caps
- Valve springs
- Valve spring retainers
- Valve spring keepers

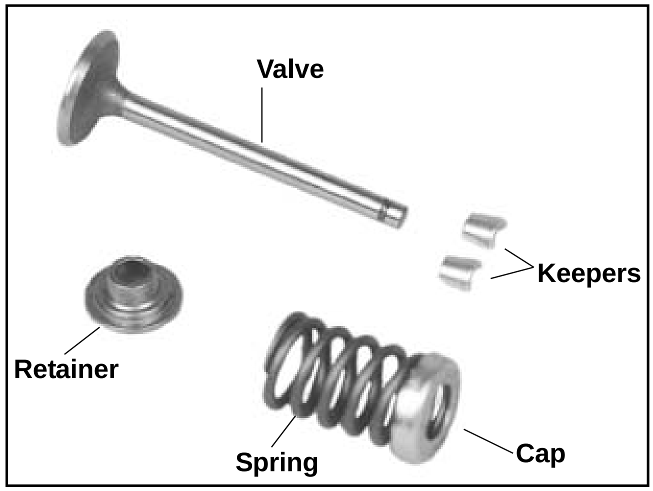


Figure 11-38. Valve Components.

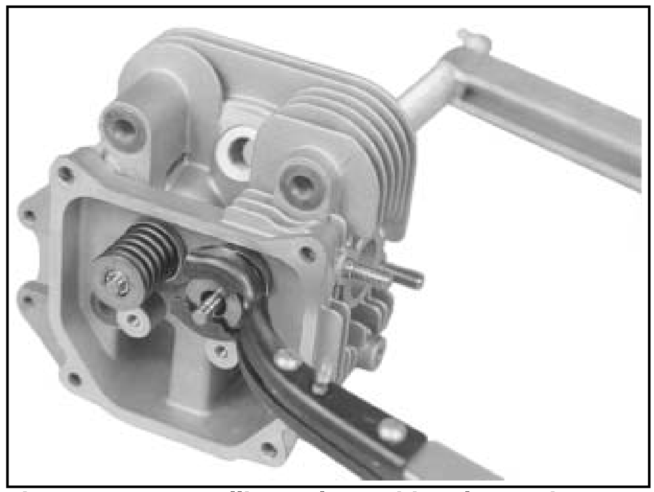


Figure 11-39. Installing Valves with Valve Spring Compressor.

Install Cylinder Heads

NOTE: Cylinder heads must be attached with the original type of mounting hardware, using either hex. flange screws, or mounting studs with nuts and washers. The heads are machined differently for studs than for screws, so the fastening method cannot be altered unless the heads are being replaced. Do not intermix the components.

1. Check to make sure there are no nicks or burrs on the sealing surfaces of the cylinder head or the crankcase.

Heads secured with hex. flange screws:

2. Install a new cylinder head gasket, (with printing up).

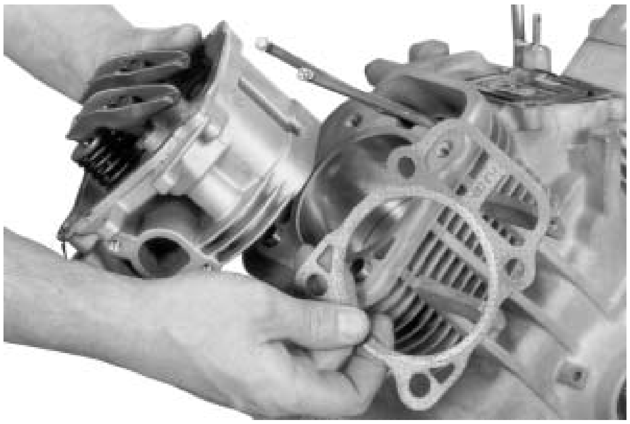


Figure 11-40. Always Use New Head Gaskets.

NOTE: Match the numbers embossed on the cylinder heads and crankcase. See Figure 11-36.

3. Install the cylinder head and start the four **new** hex. flange screws.

NOTE: When installing cylinder heads, **new** hex. flange screws should always be used.

4. Torque the hex. flange screws in two stages; first to **22.6 N·m (200 in. lb.)**, then finally to **41.8 N·m (370 in. lb.)**, following the sequence in Figure 11-42.

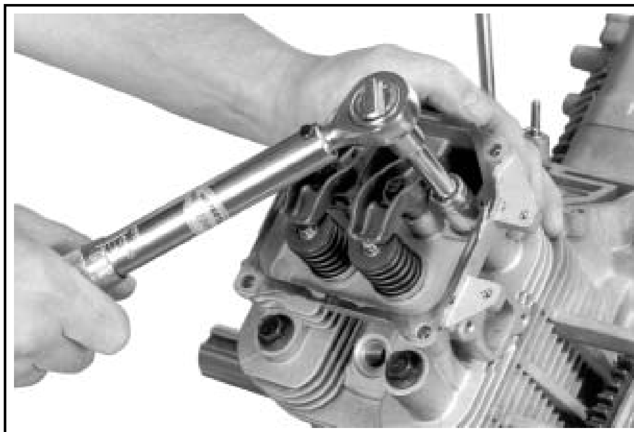


Figure 11-41. Torquing Cylinder Head Fasteners.

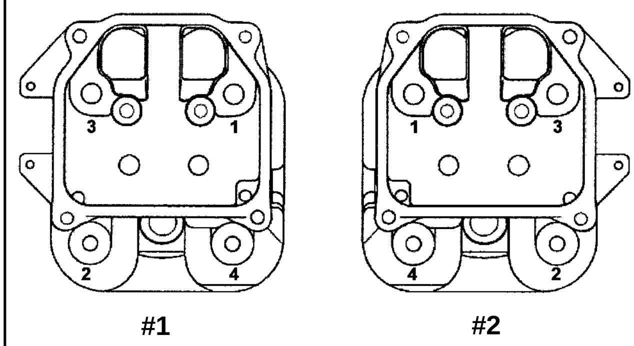


Figure 11-42. Cylinder Head Fastener Torque Sequence.

Heads secured with mounting studs, nuts, and washers:

2. If all of the studs were left intact, go to Step 6. If any studs were disturbed or removed, install new studs as described in Step 3. Do not use/reinstall any loosened or removed studs.

3. Install new mounting stud(s) into the crankcase.
   a. Thread and lock two of the mounting nuts together on the smaller diameter threads.

   b. Thread the opposite end of the stud, with the preapplied locking compound, into the crankcase, until the specified height from the crankcase surface is achieved. See Figure 11-43. When threading in the studs, use a steady tightening motion without interruption until the proper height is obtained. Otherwise, the frictional heat from the engaging threads may cause the locking compound to set up prematurely.

The studs **closest** to the lifters must have an exposed height of **75 mm (2 15/16 in.)**.

The studs **furthest** from the lifters must have an exposed height of **69 mm (2 3/4 in.)**.

   c. Remove the nuts and repeat the procedure as required.

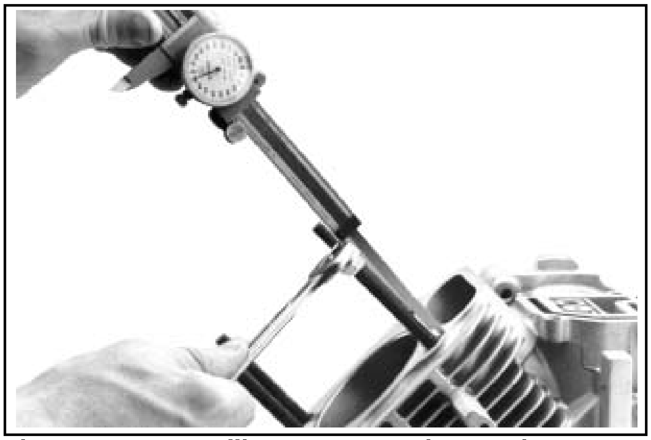


Figure 11-43. Installing New Mounting Studs to Specified Height.

4. Check that the dowel pins are in place and install a new cylinder head gasket (printing up).

5. Install the cylinder head. Match the numbers on the cylinder heads and the crankcase. See Figure 11-36. Make sure the head is flat on the gasket and dowel pins.

6. Lightly lubricate the exposed (upper) threads of the studs with engine oil. Install a flat washer and hex. nut onto each of the mounting studs. Torque the hex. nuts in two stages; first to **16.9 N·m (150 in. lb.)**, then finally to **33.9 N·m (300 in. lb.)**, following the sequence in Figure 11-42.

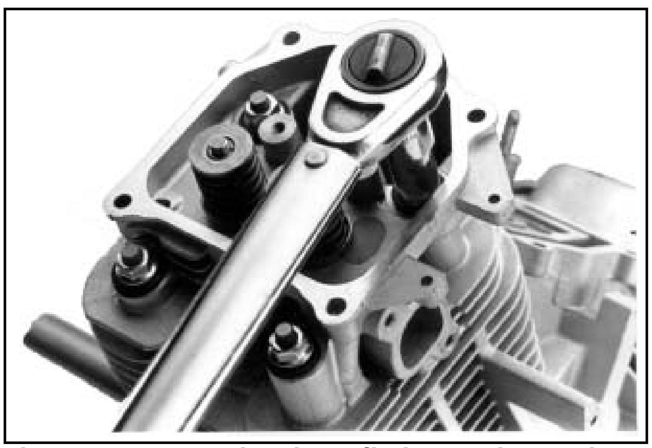


Figure 11-44. Torquing the Cylinder Head Mounting Nuts (Stud Design).

Install Push Rods and Rocker Arms

Early models used hollow push rods with special rocker arms. They are not interchangeable with the later/current style "solid" push rods and associated rocker arms. Do not mix these. A replacement kit is available with "solid" components.

NOTE: Push rods should always be installed in the same position as before disassembly.

1. Note the mark or tag identifying the push rod as either intake or exhaust and cylinder #1 or #2. Dip the ends of the push rods in engine oil and install, making sure that each push rod ball seats in its hydraulic lifter socket. See Figure 11-45.

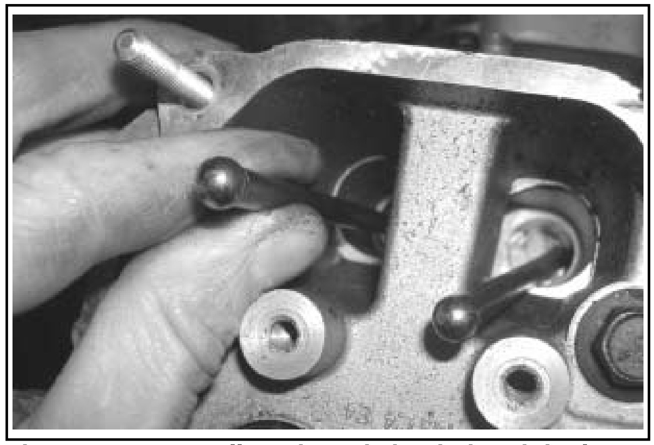


Figure 11-45. Install Push Rods in Their Original Position.

2. Apply grease to the contact surfaces of the rocker arms and rocker arm pivots. Install the rocker arms and rocker arm pivots on one cylinder head, and start the two hex. flange screws. See Figure 11-46.

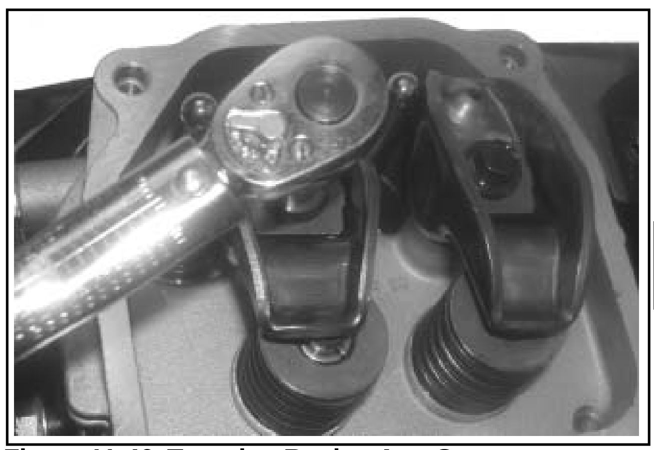


Figure 11-46. Torquing Rocker Arm Screws.

3. Torque the hex. flange screws to **11.3 N·m (100 in. lb.)**. Repeat for the other rocker arm.

4. Use a spanner wrench or rocker arm lifting tool (see Section 2), to lift the rocker arms and position the push rods underneath. See Figure 11-47.

5. Repeat the above steps for the remaining cylinder. Do not interchange parts from the cylinder heads.

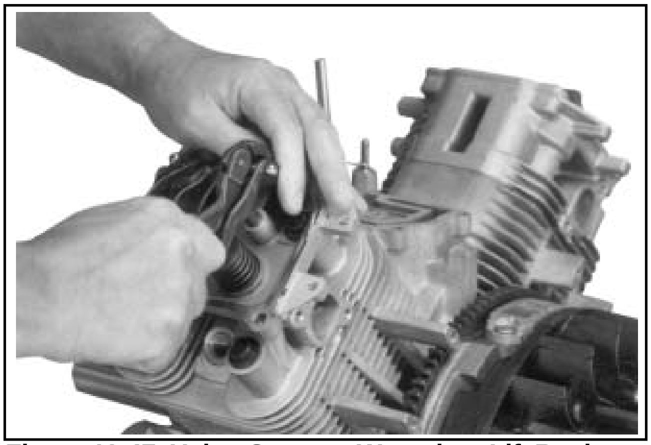


Figure 11-47. Using Spanner Wrench to Lift Rocker Arm Over Push Rod.

6. Rotate the crankshaft to check for free operation of the valve train. Check the clearance between the valve spring coils at full lift. Minimum allowable clearance is **0.25 mm (0.010 in.)**.

Install Spark Plugs

1. Use new Champion® (or equivalent) spark plugs.

2. Set the gap at 0.76 mm (0.030 in.).

3. Install new plugs and torque to **24.4-29.8 N·m (18-22 ft. lb.)**. See Figure 11-48.

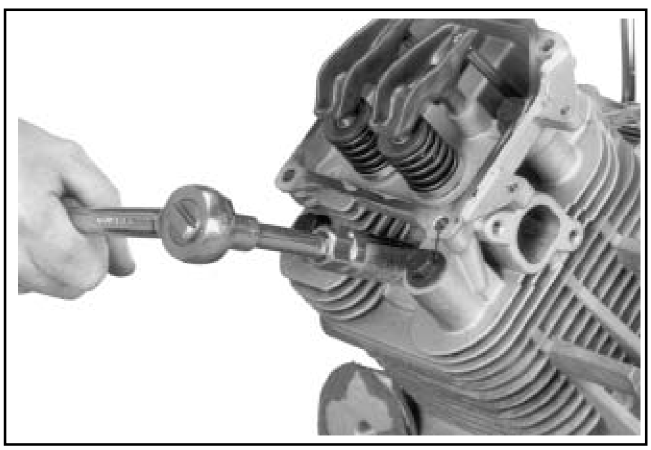


Figure 11-48. Installing Spark Plugs.

Install Ignition Modules

1. Rotate the flywheel to position the magnet away from the ignition module bosses.

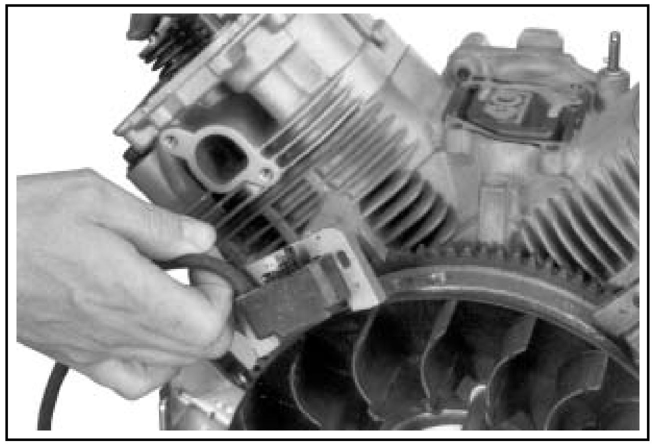


Figure 11-49. Installing Ignition Module.

2. On engines equipped with SMART-SPARK™ both modules are installed the same way - with the two tabs out. See Figure 11-55.

   On engines are not equipped with SMART-SPARK™ the modules are installed with the spark plug lead wire from module always away from the cylinder. On #1 cylinder, the single kill tab should be towards you. See Figure 11-54. On #2 cylinder, the single kill tab should be away from you (in).

3. Install each ignition module to the crankcase bosses with the two screws (hex. flange or allen head, based on model). Slide the modules up as far away from the flywheel as possible and snug the screws to hold them in that position.

4. Rotate the flywheel to position the magnet directly under one ignition module.

5. Insert a **0.30 mm (0.012 in.)** flat feeler gauge between the magnet and the ignition module. See Figure 11-50. Loosen the screws enough to allow the magnet to pull the module down against the feeler gauge.

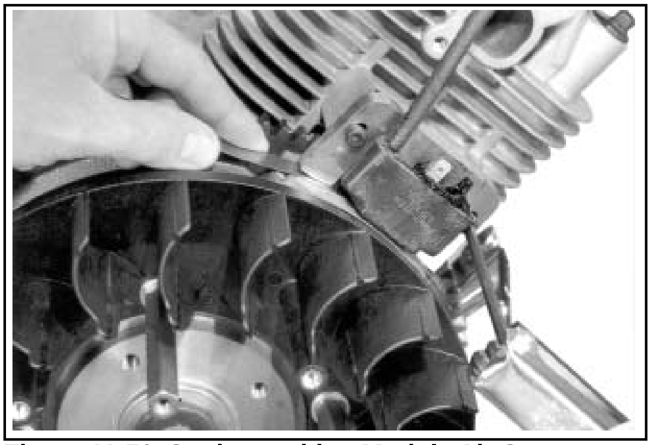


Figure 11-50. Setting Ignition Module Air Gap.

6. Torque the screws to **4.0 N·m (35 in. lb.)**.

7. Repeat steps 4 through 6 for the other ignition module.

8. Rotate the flywheel back and forth checking for clearance between the magnet and ignition modules. Make sure the magnet does not strike the modules. Check the gap with a feeler gauge and readjust if necessary. Final Air Gap: **0.280/0.330 mm. (0.011/0.013 in.)**.

Install Intake Manifold

1. Install the intake manifold and new gaskets or O-Rings (plastic manifold), with wiring harness attached, to the cylinder heads. Slide any wiring harness clips onto the appropriate bolts before installing. Make sure the gaskets are in the proper orientation. Torque the four screws in two stages, first to **7.4 N·m (66 in. lb.),** then to **9.9 N·m (88 in. lb.),** using the sequence shown in Figure 11-51.

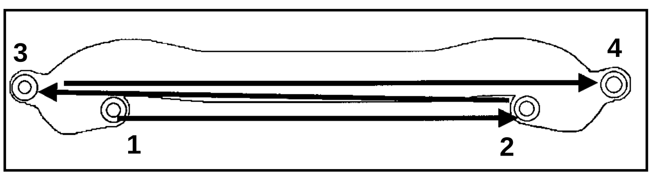


Figure 11-51. Intake Manifold Torque Sequence.

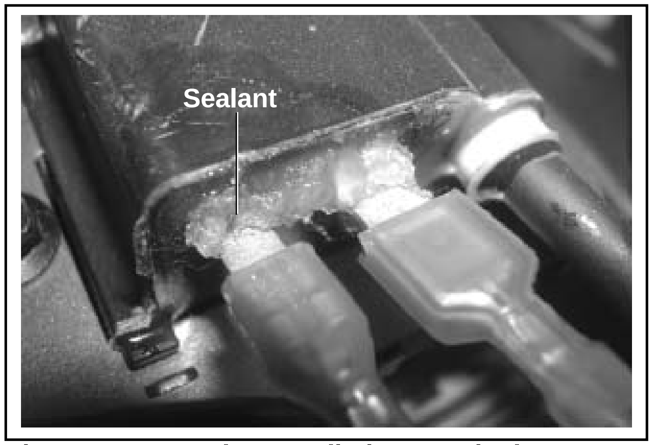


Figure 11-52. Sealant Applied to Terminals.

NOTE: If the wires were disconnected from the ignition modules on engines with SMART-SPARK™, reattach the leads and seal the base of the terminal connectors with GE/ Novaguard G661 (Kohler Part No. **25 357 11-S)** or Fel-Pro Lubri-Sel dielectric compound. The beads should overlap between the terminals* to form a solid bridge of compound. See Figure 11-52. Do not put any compound inside the terminals.

*The 24 584 15-S ignition modules have a separator barrier between the terminals. On these modules, seal the base of the terminals, but it is not necessary to have overlapping beads of sealant between the connections.

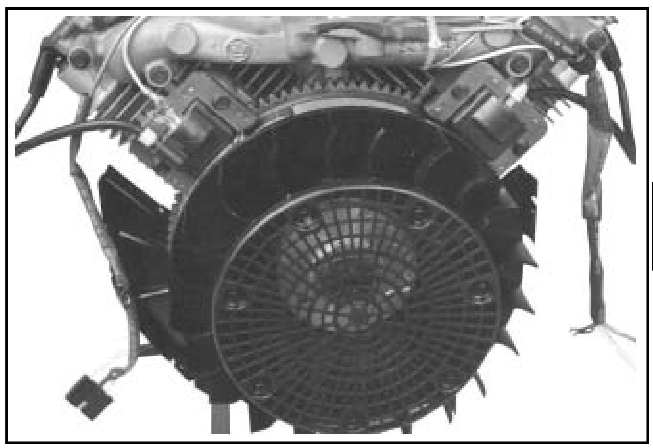


Figure 11-53. Routing of Wiring Harness.

2. Connect the kill lead to the tab terminal on standard ignition modules. See Figure 11-54.

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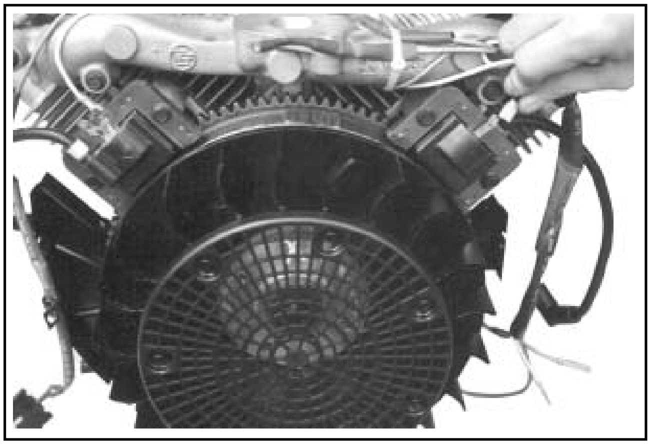


Figure 11-54. Connecting Kill Leads on Standard Ignition Modules.

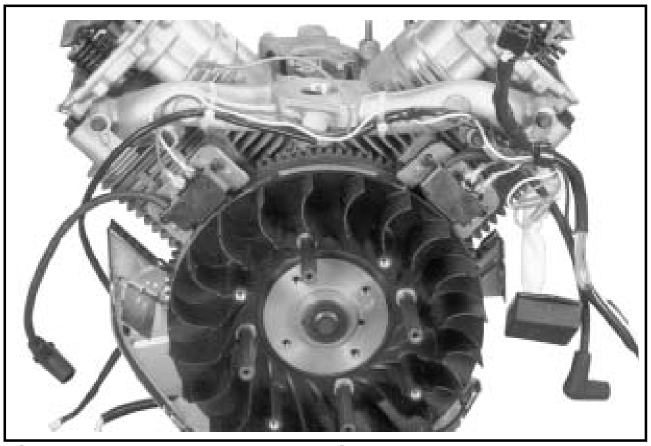


Figure 11-55. Connect Leads on SMART-SPARK™ Ignition Modules.

Install Breather Cover and Inner Baffles

RTV sealant was used on early models between the breather cover and the crankcase. A gasket with imprinted sealant beads is now used and recommended. Install as follows:

1. Be sure the sealing surfaces of the crankcase and breather cover are clean of old gasket material or RTV sealant. **Do not** scrape the surfaces as this could result in leakage.

2. Check to make sure there are no nicks or burrs on sealing surfaces.

3. Install the hex. flange screw, breather reed retainer and breather reed onto the crankcase as shown in Figure 11-56.

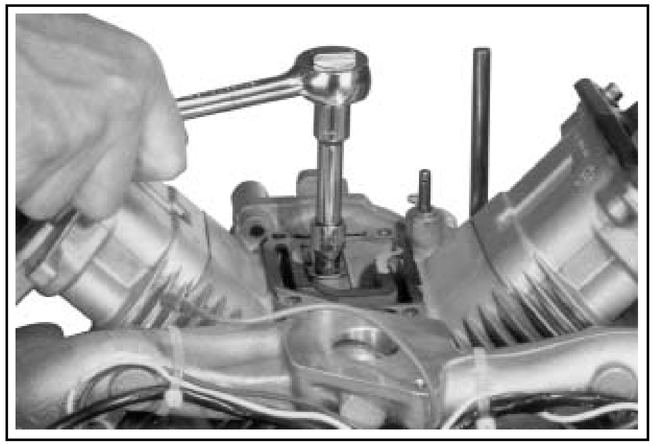


Figure 11-56. Installing Breather Reed Assembly.

4. Insert the breather filter into position in the crankcase. Make sure no filter strands are on the sealing surface. See Figure 11-57.

5. Install the new breather gasket.

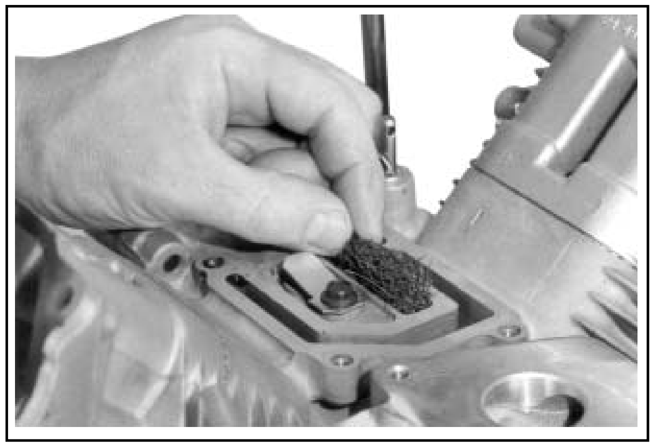


Figure 11-57. Installing New Breather Filter.

6. Carefully position the breather cover on the crankcase. Install first two hex. flange screws at positions shown in Figure 11-58 and finger tighten at this time.

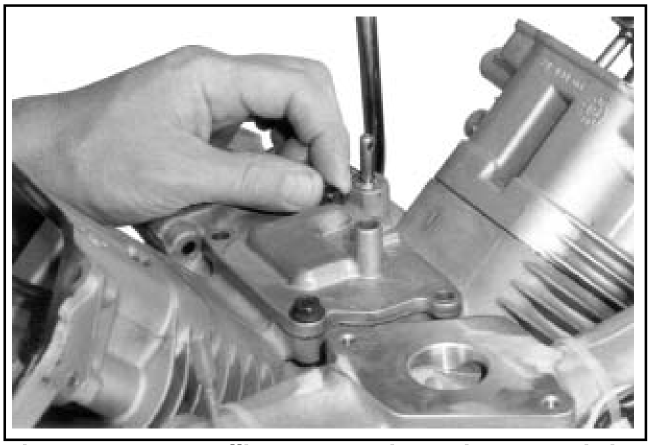


Figure 11-58. Installing Screws (Locations 3 and 4).

7. Install the inner baffles using the two remaining hex. flange screws (see Figures 11-59 and 11-60) and finger tighten. **Do not** torque the screws at this time; they will be tightened after the blower housing and outer baffles are installed.

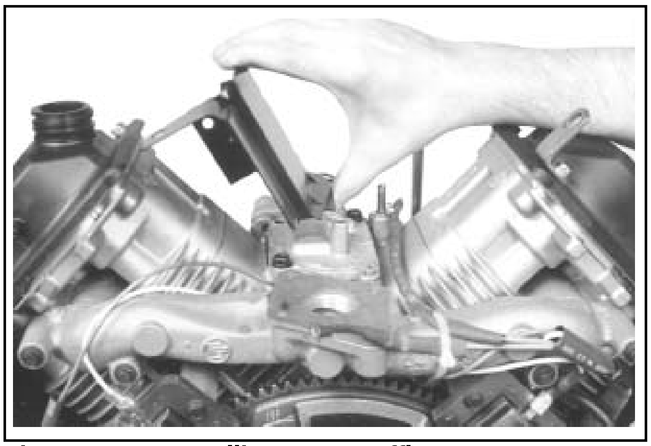


Figure 11-59. Installing Inner Baffles.

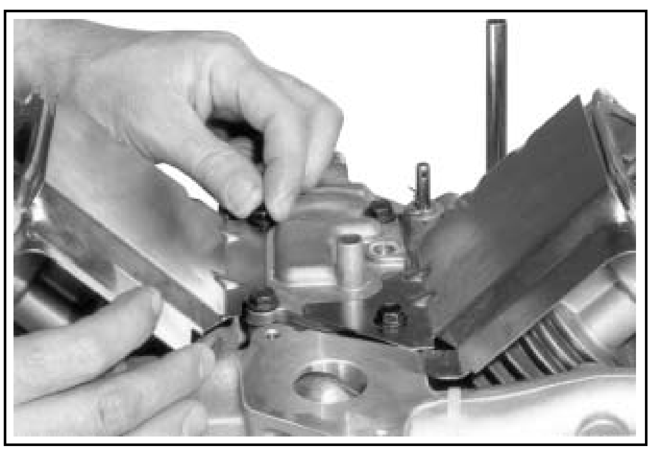


Figure 11-60. Finger Tighten Two Remaining Cover Screws.

Install Blower Housing and Outer Baffles

NOTE: Do not completely tighten screws until all items are installed to allow shifting for hole alignment.

1. Connect the plug to the key switch in the blower housing (if so equipped).
2. Slide the blower housing into position over the front edge of the inner baffles. See Figure 11-61. Start a few of the screws to hold it in place.

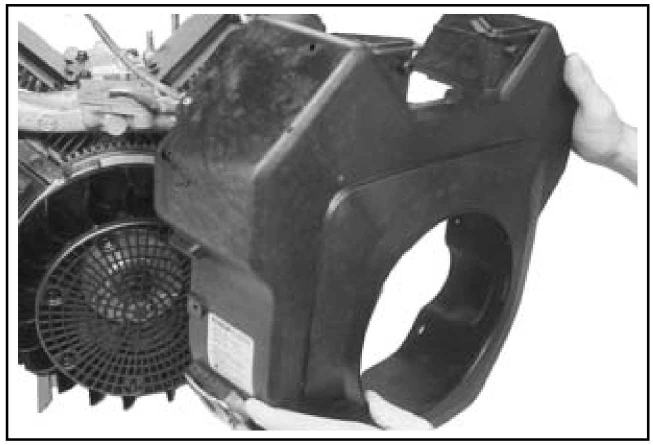


Figure 11-61. Installing Blower Housing.

3. Position the outer baffles and loosely start the mounting screws. The two M6 screws go into the back of the cylinders. The short M5 screws go into the lower holes closest to the blower housing. The short screw on the oil filter side is also used to mount the wire harness clip. Be sure any wire harnesses or leads are routed out through the proper offsets or notches, so they will not be pinched between the blower housing and baffles. See Figure 11-62.

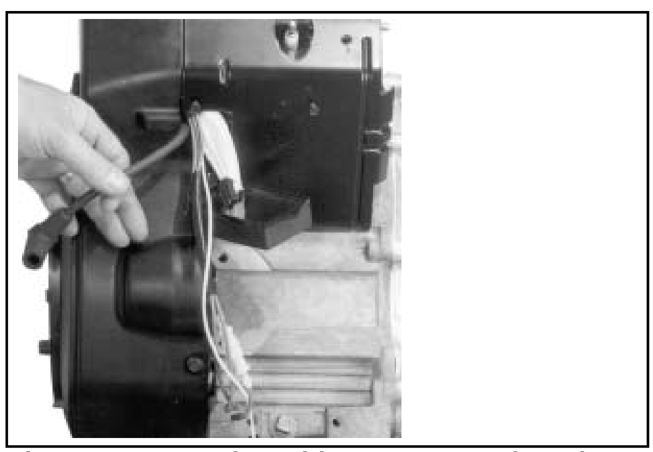


Figure 11-62. Routing Wiring Harness and Leads.

4. If the rectifier-regulator was not removed, attach the ground wire or metal grounding bracket for the rectifier-regulator, using the silver colored screw and washer, to the lower blower housing hole. See Figure 11-63.

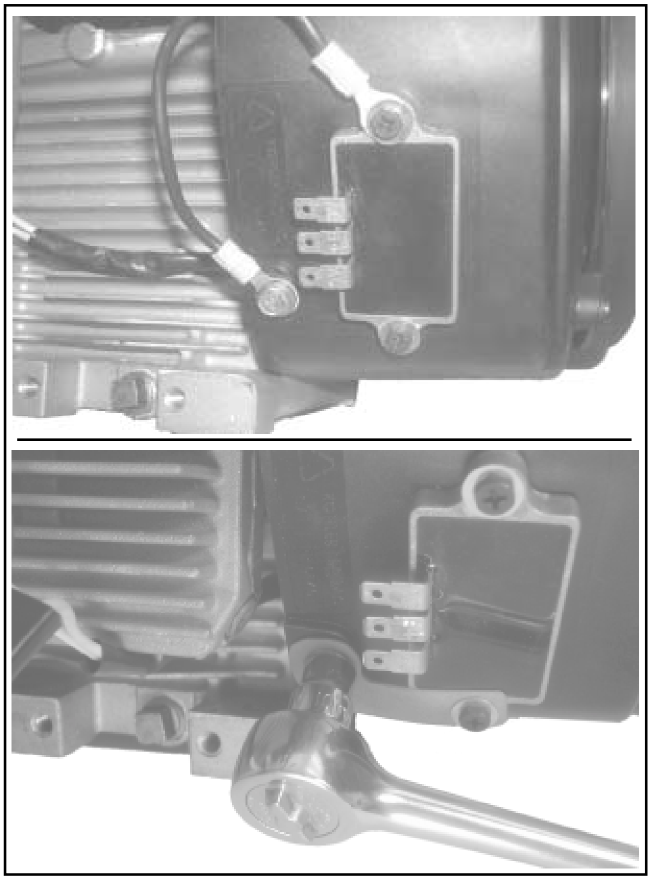


Figure 11-63. Ground Lead Details.

5. Tighten all of the shrouding fasteners. Torque the blower housing screws to **6.2 N·m (55 in. lb.)** in a new hole, or to **4.0 N·m (35 in. lb.)** in a used hole. Torque the shorter M5 side baffle screws to **4.0 N·m (35 in. lb.)**. See Figure 11-64. Torque the upper M5 side baffle screws (into cylinder head) to **6.2 N·m (55 in. lb.)** in a new hole, or to **4.0 N·m (35 in. lb.)** in a used hole. Torque the two rear M6 baffle mounting screws to **10.7 N·m (95 in. lb.)** in a new hole, or to **7.3 N·m (65 in. lb.)** in a used hole. See Figure 11-65.

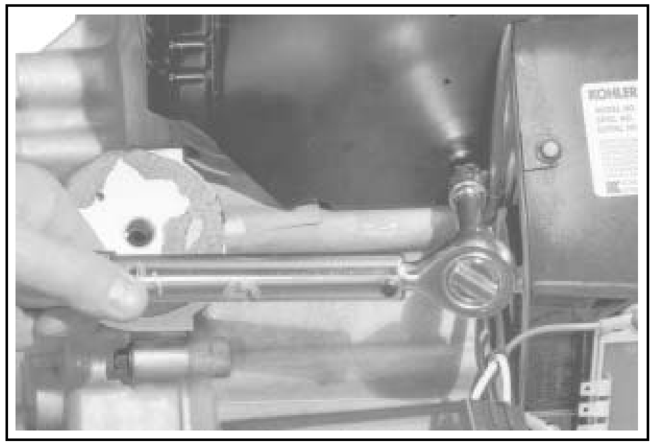


Figure 11-64. Tighten Short Screws to Torque Specified.

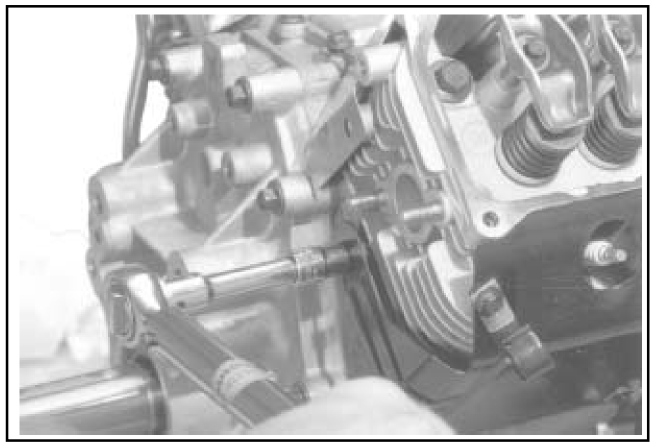


Figure 11-65. Tighten Baffle Mounting Screws.

6. The metal grass screen can now be attached to the supports.

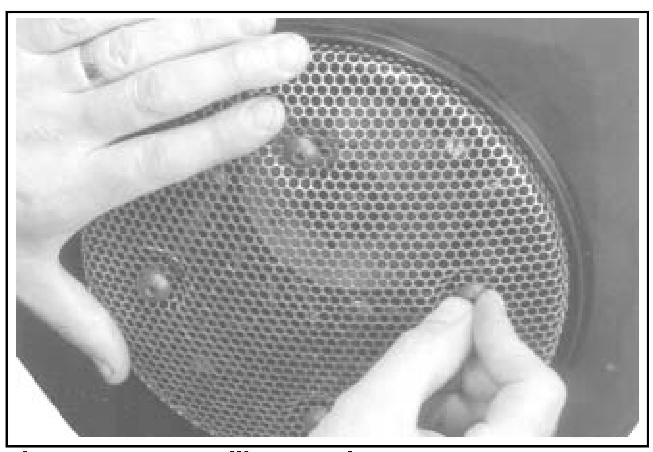


Figure 11-66. Installing Metal Type Grass Screen.

7. Torque the four breather cover screws to **7.3 N·m (65 in. lb.)** in the sequence shown in Figure 11-67.

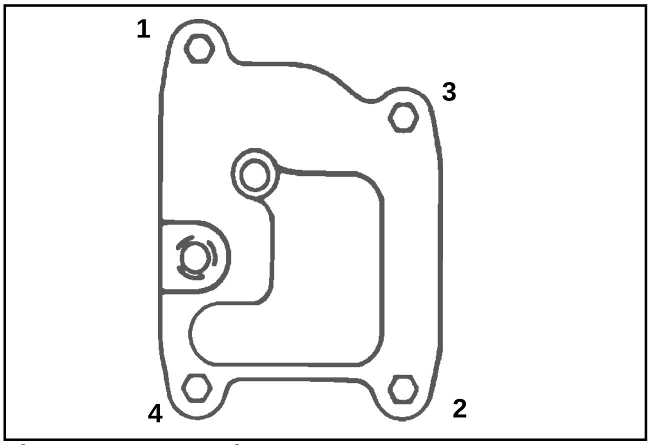


Figure 11-67. Breather Cover Fastener Torque Sequence.

Reconnect Rectifier-Regulator

1. Install the rectifier-regulator in the blower housing, if removed previously, then connect the rectifier-regulator ground lead with the washer and silver screw through the eyelet as shown in Figure 11-68. If a grounding bracket is used, secure with the lower mounting screw and washer, against the **outer** side of the rectifier-regulator. See Figure 11-70.

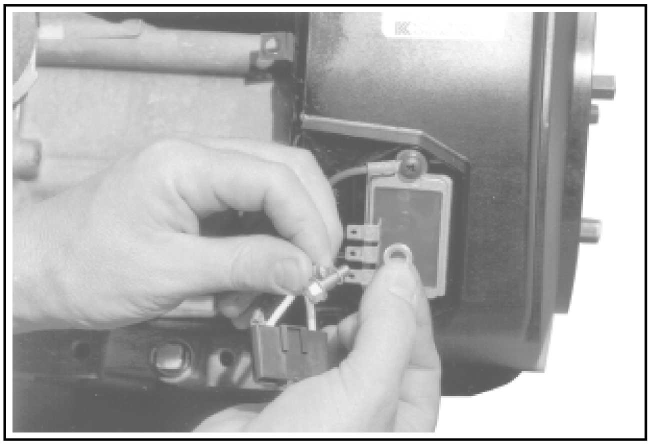


Figure 11-68. Connecting Ground Lead.

2. Install the B+ terminal/lead into the center position of the rectifier-regulator plug and connect the plug to the rectifier-regulator. See Figures 11-69 and 11-70.

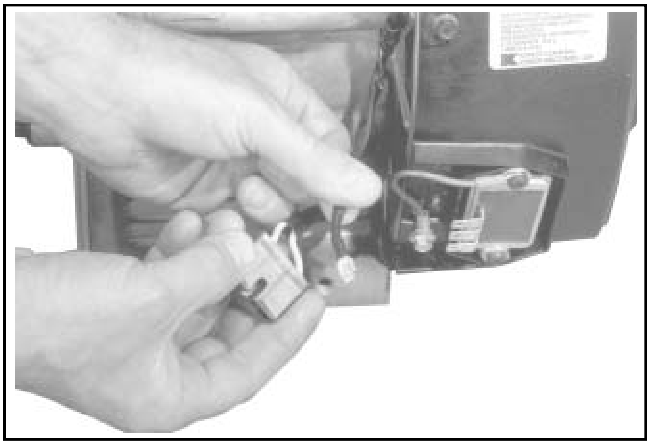


Figure 11-69. Installing B+ Lead into Plug.

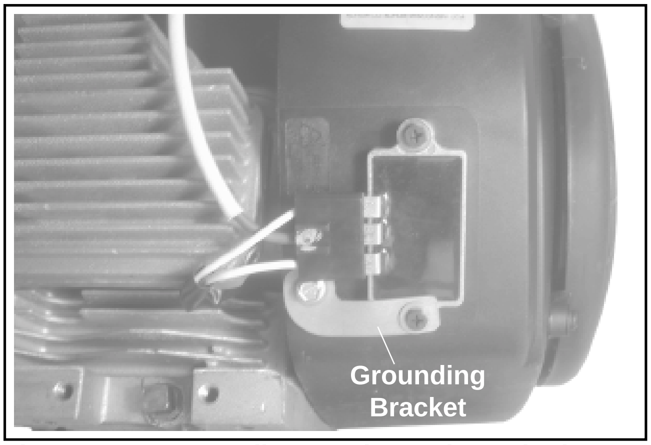


Figure 11-70. Grounding Bracket and Attached Connector.

SMART-SPARK™ Module

1. On engines with SMART-SPARK™, reinstall the SAM module to the blower housing or cylinder baffle. Do not over-tighten the retaining screws. See Figure 11-71.

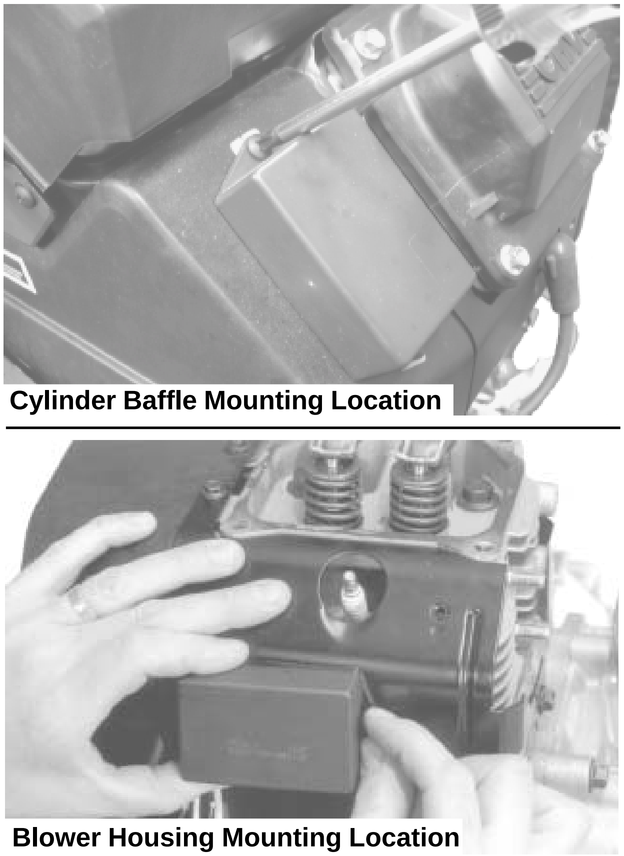


Figure 11-71. Reinstalling SAM Module.

Install Electric Starter Motor

1. Install the starter motor using the two hex. flange screws. See Figure 11-72. Some inertia-drive starters have a pinion cover and spacers on the starter bolts.

2. Torque the two hex. flange screws to **15.3 N·m (135 in. lb.)**.

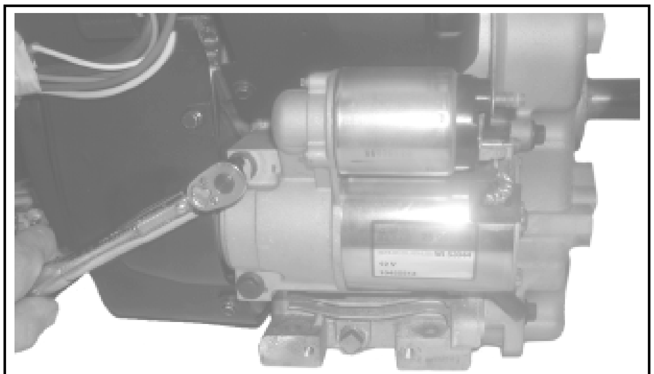


Figure 11-72. Installing Electric Starter Motor.

3. On models with a solenoid shift starter, connect the leads to the solenoid. See Figure 11-73.

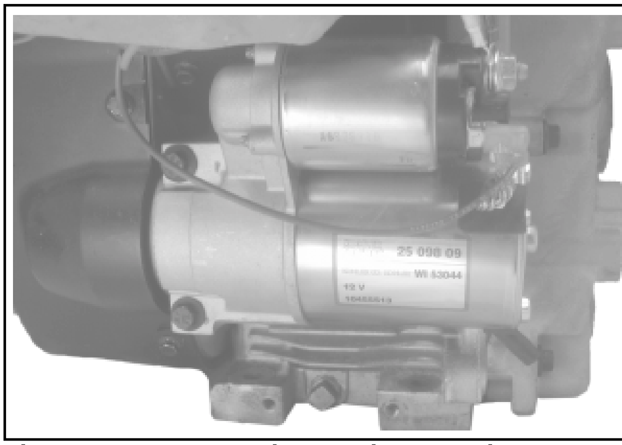


Figure 11-73. Connecting Leads to Starting Motor.

NOTE: If the engine uses a side mount muffler on the starter side, be sure to tie the wires close to the starter to avoid contact with hot exhaust parts.

Install Fuel Pump

WARNING: Explosive Fuel

Gasoline may be present in the carburetor and fuel system. Gasoline is extremely flammable and its vapors can explode if ignited. Keep sparks and other sources of ignition away from the engine.

1. Install the pulse style fuel pump and lines as an assembly. Connect the pulse line to the crankcase vacuum fitting or the valve cover, whichever source is used.

   NOTE: Pulse style fuel pumps may be made of metal or plastic. See Figure 11-74. If a new fuel pump is being installed, make sure the orientation of the new pump is consistent with the removed pump. Internal damage may occur if installed incorrectly.

2. Install the fuel pump using the two hex. flange screws. Torque the screws to **2.3 N·m (20 in. lb.)**.

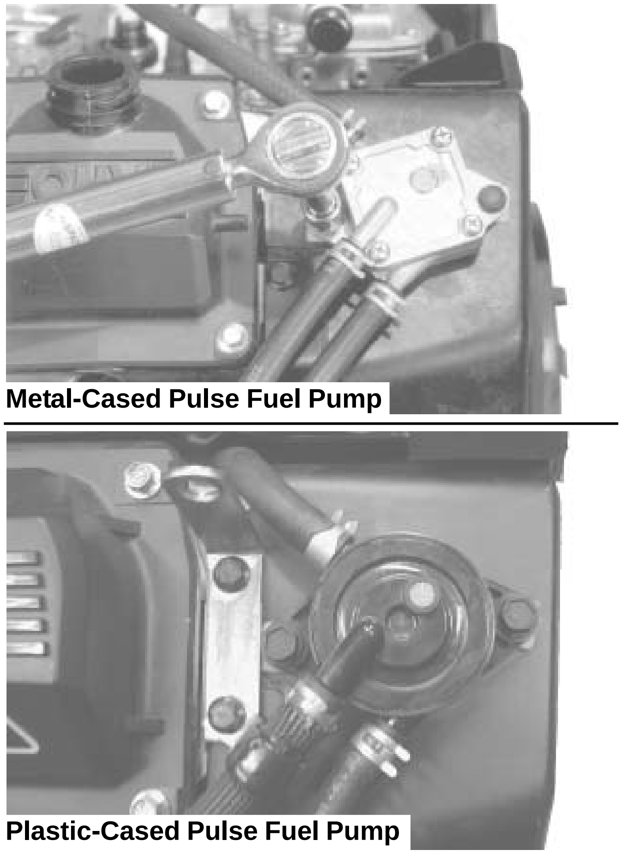


Figure 11-74. Reinstalled Fuel Pump.

Install Carburetor

WARNING: Explosive Fuel!
Gasoline may be present in the carburetor and fuel system. Gasoline is extremely flammable and its vapors can explode if ignited. Keep sparks and other sources of ignition away from the engine.

1. Install a new carburetor gasket. Make sure all holes align and are open.

2. Install the carburetor, throttle linkage and governor lever as an assembly. See Figure 11-75. If a plastic intake manifold is used and the carburetor is equipped with a fuel solenoid, attach the ground lead to the carburetor mounting screw. See Figure 11-76.

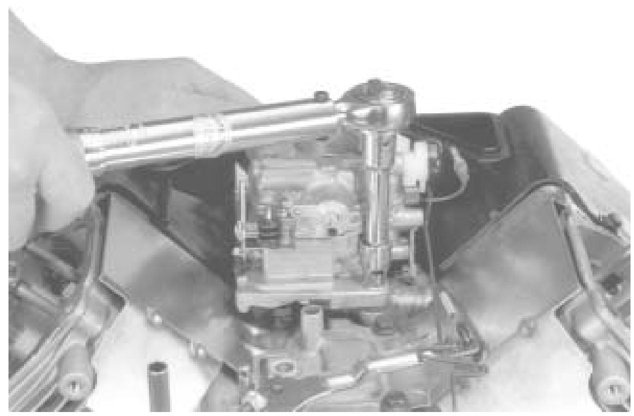


Figure 11-75. Installing Carburetor Assembly.

Figure 11-76. Ground Lead on Carburetor Mounting Screw.

3. Torque the two carburetor mounting screws to **6.2-7.3 N·m (55-65 in. lb.)**.

Install External Governor Controls

1. Install the governor lever onto the governor cross shaft. See Figure 11-77.

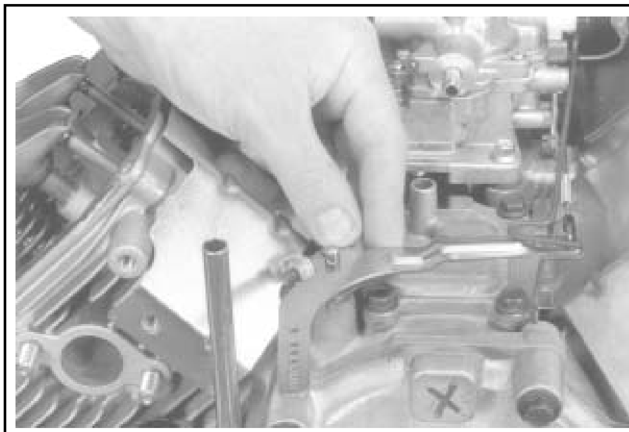


Figure 11-77. Install Governor Lever to Shaft.

2. Make sure the throttle linkage is connected to the governor lever and the throttle lever on the carburetor.

3. Move the governor lever **toward** the carburetor as far as it will go (wide-open throttle) and hold in position. See Figure 11-78.

Figure 11-78. Adjusting Governor Lever.

4. Insert a nail into the hole on the cross shaft and rotate the shaft **counterclockwise** as far as it will turn, then torque the hex. nut to **6.8 N·m (60 in. lb.)**. See Figure 11-79.

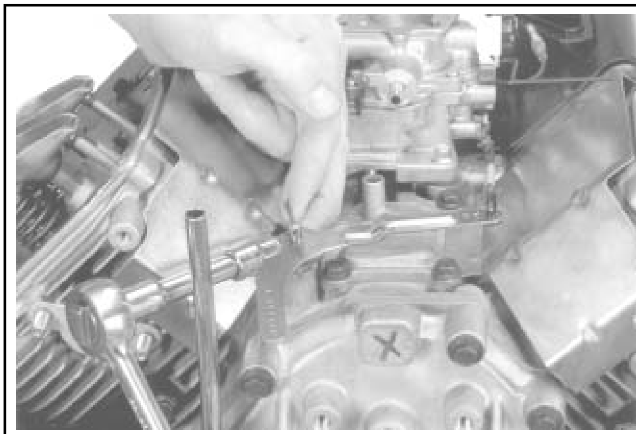


Figure 11-79. Holding and Tightening Governor Arm.

5. Reconnect the lead wire to the fuel shut-off solenoid if so equipped.

Install Throttle & Choke Controls

1. Connect the choke linkage to the carburetor and choke actuator lever. See Figure 11-80.

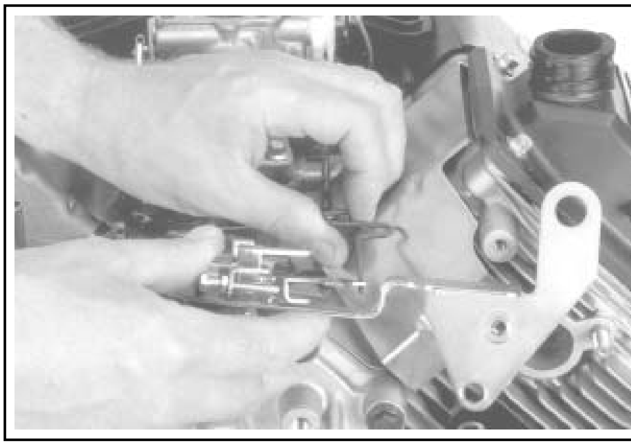


Figure 11-80. Connecting Choke Linkage.

2. Mount the main control bracket, and air cleaner support bracket (if used) to the cylinder heads using the four hex. flange screws. Torque the screws to **10.7 N·m (95 in. lb.)** into new holes, or **7.3 N·m (65 in. lb.)** into used holes. See Figure 11-81.

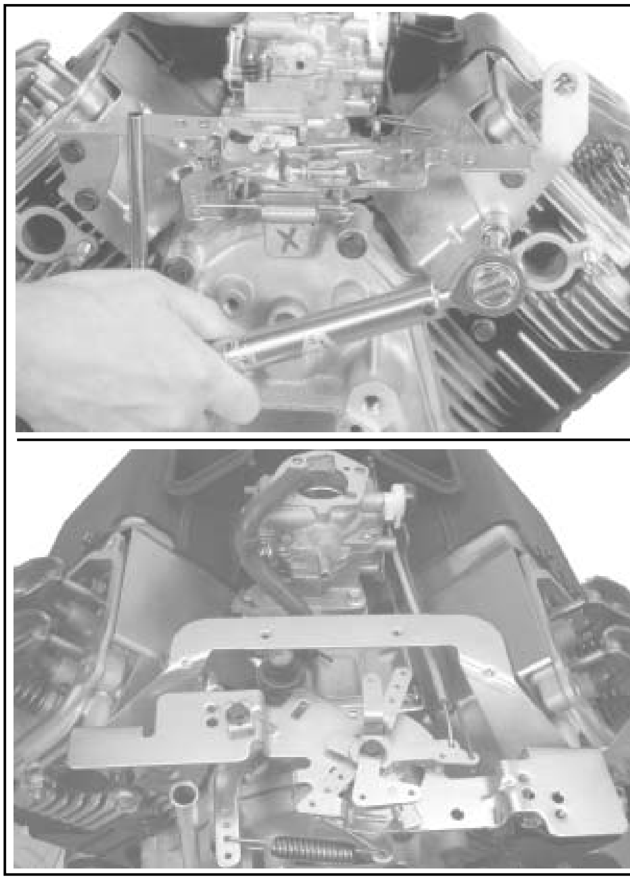


Figure 11-81. Torquing Main Control Bracket.

3. Connect the governor spring from the main control bracket to the appropriate hole in the governor lever as indicated in the following charts. Note that hole positions are counted from the pivot point of the governor lever. See Figure 11-82 and the appropriate chart.

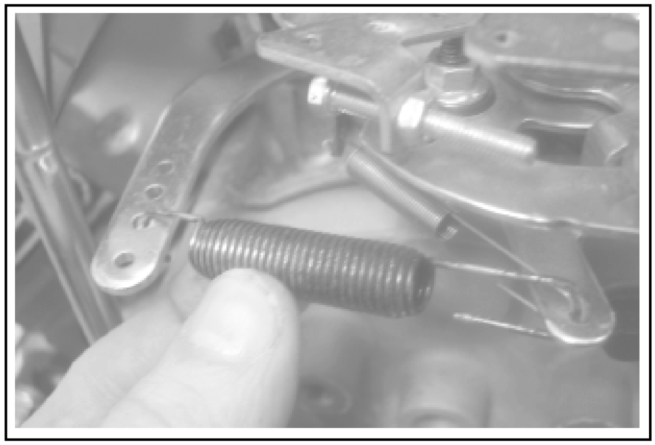
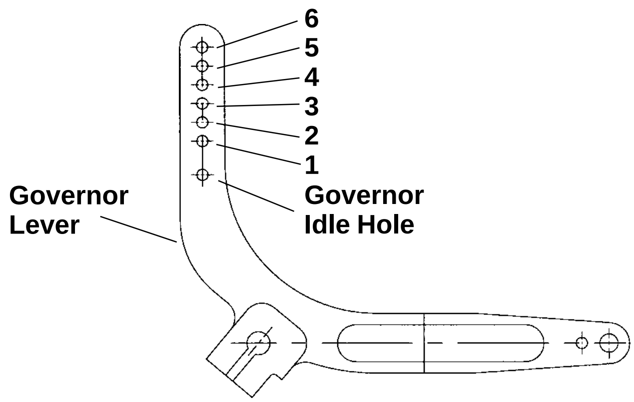


Figure 11-82. Connecting Spring to Governor Lever.

6 mm Governor Lever and Hole Position/RPM Chart

High Idle RPM	Gov. Lever Hole No.	Governor Spring Color Code
3801-4000	5	Clear
3601-3800	4	Clear
3451-3600	3	Clear
3301-3450	2	Clear
3101-3300	4	Purple
2951-3100	3	Purple
2800-2950	2	Purple
3750*	3	Clear
3150*	3	Purple

*5% Regulation (others 10%)



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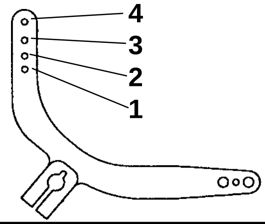
8 mm Governor Lever and Hole Position/RPM Charts



CH18 Engines

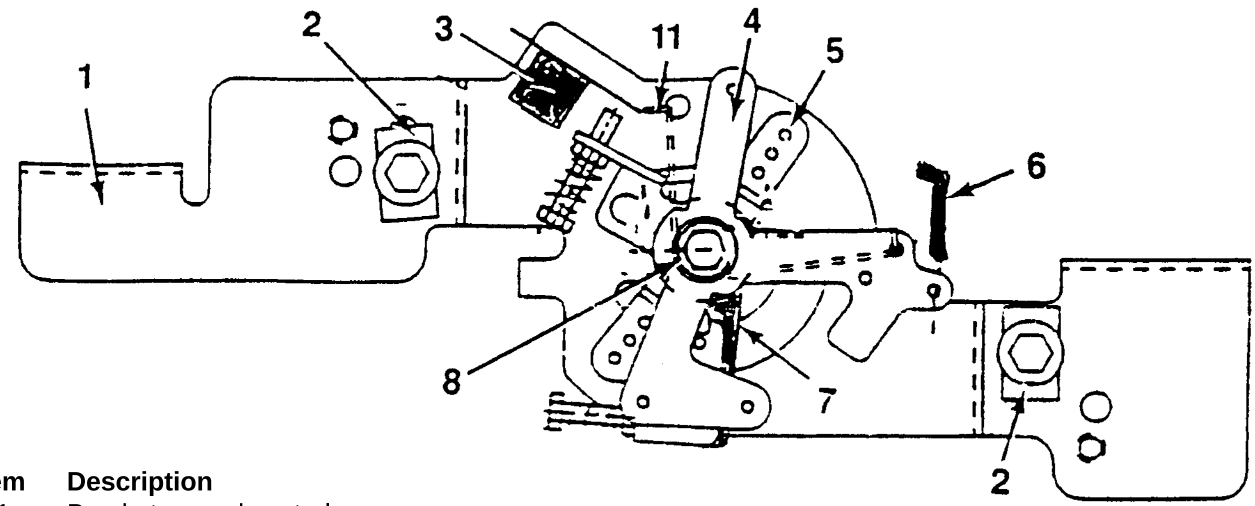
Governor Shaft Configuration	Intended Maximum RPM		Non-Accelerator Pump Carburetor		Accelerator Pump Carburetor	
	High Idle	WOT	Spring Color	Hole No.	Spring Color	Hole No.
Needle Bearing	3744	3600	Orange	2	-	-
	3120	3000	Clear	1	-	-
Standard (Parent Material)	3888	3600	Blue	4	Purple	3
	3780	3500	Orange	3	Black	3
	3672	3400	Clear	4	Red	3
	3564	3300	Blue	3	Orange	2
	3456	3200	Purple	2	Blue	2
	3348	3100	Black	2	Orange	1
	3240	3000	Red	2	Black	1
	3132	2900	Green	1	Red	1
	3024	2800	Blue	1	Clear	1

CH20-740 Engines

Governor Shaft Configuration	Intended Maximum RPM		Non-Accelerator Pump Carburetor		Accelerator Pump Carburetor	
	High Idle	WOT	Spring Color	Hole No.	Spring Color	Hole No.
Needle Bearing	3744	3600	Orange	2	-	-
	3120	3000	Clear	1	-	-
Standard (Parent Material)	3888	3600	Red	4	Purple	3
	3780	3500	Purple	3	Black	3
	3672	3400	Black	3	Red	3
	3564	3300	Red	3	Orange	2
	3456	3200	Purple	2	Blue	2
	3348	3100	Blue	2	Orange	1
	3240	3000	Orange	1	Black	1
	3132	2900	Clear	2	Red	1
	3024	2800	Red	1	Clear	1

CH26,CH745 EFI Engines

Governor Shaft Configuration	Intended Maximum RPM			
	High Idle	WOT	Spring Color	Hole No.
Standard (Parent Material)	3888	3600	Orange	3
	3780	3500	Black	3
	3672	3400	Red	3
	3564	3300	Green	2
	3456	3200	Red	2
	3348	3100	Green	1
	3240	3000	Blue	1
	3132	2900	Clear	1
	3024	2800	-	-



Item	Description
1	Bracket, speed control
2	Clamp, cable (some applications)
3	Kill Switch (some applications)
4	Lever, choke (top position)
5	Lever, throttle control (middle)
6	Linkage, choke control
7	Lever, throttle actuator (bottom)
8	Screw, M5x0.8x20
9	Washer, wave
10	Washer, flat (3)
11	Spring, choke return
12	Nut, M5x0.8 lock

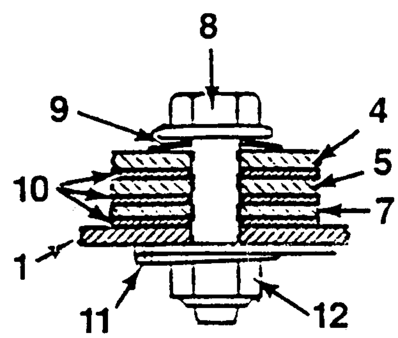


Figure 11-83. Throttle/Choke Control Bracket Detail.

Install Oil Sentry™ (If So Equipped)

1. Apply **pipe sealant with Teflon®** (Loctite® No. 59241 or equivalent) to the threads of the Oil Sentry™ switch and install it into the breather cover. See Figure 11-84. Torque to **4.5 N·m (40 in. lb.)**.

2. Connect the wire lead (green) to the Oil Sentry™ terminal.

Figure 11-84. Installing Oil Sentry™ Switch.

Install Control Panel (If So Equipped)

1. Install the panel to the blower housing.

2. Connect the throttle control cable or shaft.

3. Connect the choke control cable to the control bracket.

4. Connect the Oil Sentry™ indicator light wires.

11

Install Valve Covers

Three valve cover designs have been used. The earliest type used a gasket and RTV sealant between the cover and sealing surface of the cylinder head. The second type had a black O-Ring installed in a groove on the underside of the cover and may have metal spacers in the bolt holes. The newest design uses a brown O-Ring, and the bolt hole spacers are molded in place. The tightening torque differs between gasket and O-Ring style covers. Kits are available for converting to the latest O-Ring type covers. Differences are pointed out in the following installation steps.

NOTE: Do not scrape old RTV sealant (if used) off the sealing surface of the cylinder head as this could cause damage and result in leaks. The use of gasket remover solvent (paint remover) is recommended.

1. If using the gasket or sealant type cover, prepare the sealing surfaces of the cylinder head and cover as directed in Service Bulletin 252. Refer to Section 2, for approved sealants. Always use fresh sealant – using outdated sealant could result in leakage. With O-Ring type covers, make sure the sealing surfaces are clean.

2. Make sure there are no nicks or burrs on the sealing surfaces.

3. For covers requiring RTV sealant, apply a 1.5 mm (1/16 in.) bead to the sealing surface of both cylinder heads, install a new valve cover gasket on each, then apply a second bead of sealant on the top surface of the gaskets. For O-Ring type covers, install a new O-Ring in the groove of the covers. **Do not** use gaskets or RTV sealant.

4. Locate the cover with the oil fill neck on the same side as removed and install the lifting strap in the original position. With O-Ring type covers, position the cover on the cylinder head. If loose spacers were used, insert a spacer in each of the screw holes. On both types, install the four hex. flange screws in each cover and finger tighten.

5. Torque the valve cover fasteners to the proper specification using the sequence shown in Figure 11-85.

Gasket/RTV style cover .... 3.4 N·m (30 in. lb.)
Black O-Ring style cover
  with shoulder screws .... 5.6 N·m (50 in. lb.)
  with screws and spacers ..... 9.9 N·m (88 in. lb.)
Brown O-Ring style cover
  with integral spacers .... 9.9 N·m (88 in. lb.)

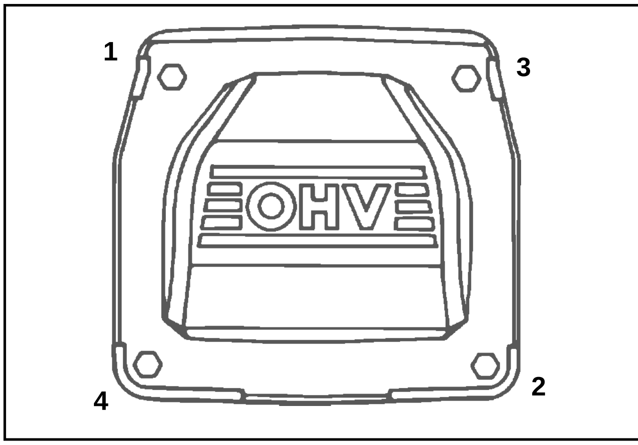


Figure 11-85. Valve Cover Fastener Torque Sequence.

NOTE: Fastener #2 may secure fuel pump bracket on earlier models.

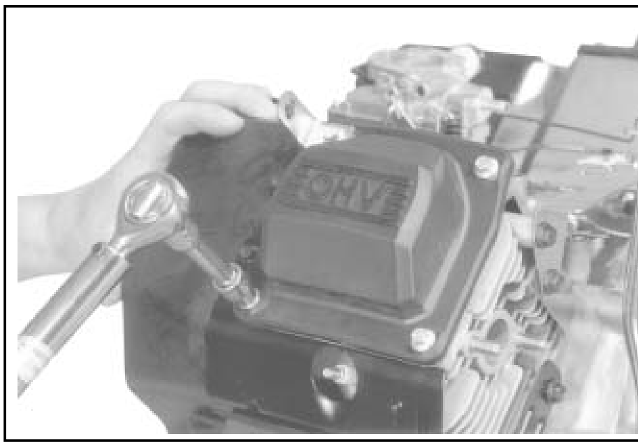


Figure 11-86. Tightening Valve Cover Screws.

Install Air Cleaner Assembly

Refer to Section 4 for air cleaner reassembly procedure.

1. Attach the rubber breather hose to the breather cover. Connect the fuel inlet line to the carburetor and secure with a clamp. See Figure 11-87.

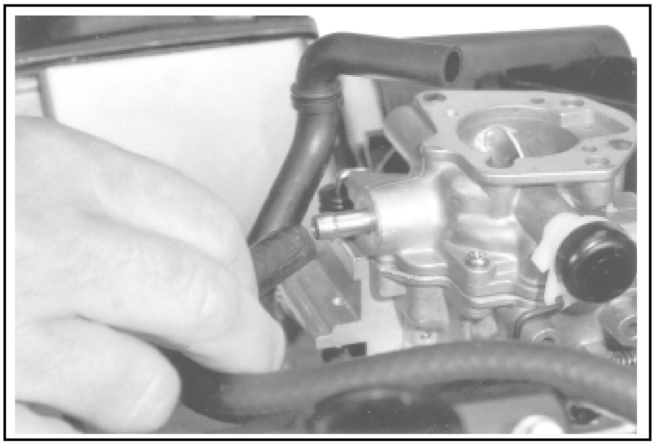


Figure 11-87. Connecting Fuel Inlet Line.

2. Position a new gasket and the air cleaner base while carefully pulling the loose end of the rubber breather hose through the base until properly seated (collars sealed against each side of base). See Figure 11-88.

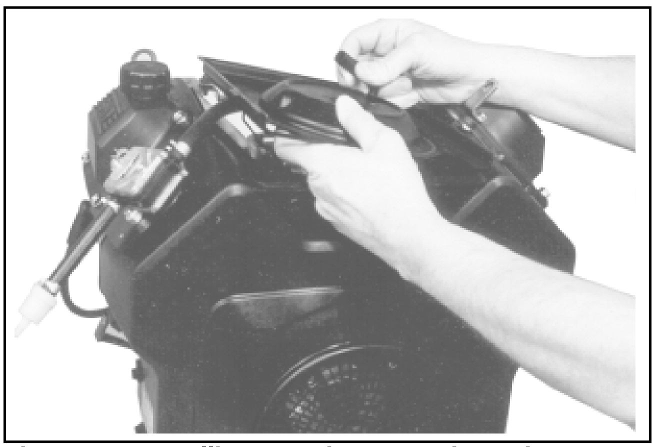


Figure 11-88. Pulling Breather Hose through Base.

NOTE: Route the fuel line in the contour, as shown in Figure 11-89, to avoid restriction.

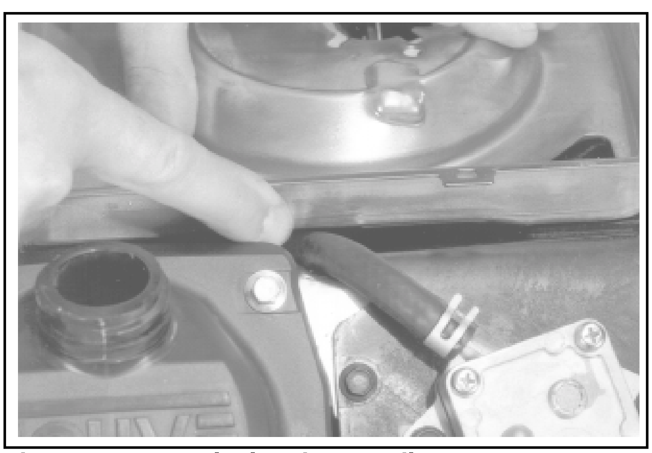


Figure 11-89. Fuel Inlet Line Detail.

3. Secure the air cleaner base and bracket using the hex. flange screws. Position the bracket with the hole toward the breather hose. Be careful not to drop screws into the carburetor. If a rear air cleaner bracket is used, install the two M5 screws through the rear of the base. Torque the three M6 screws to **6.2-7.3 N·m (55-65 in. lb.)** and the two rear M5 mounting screws (when applicable) to **4.0 N·m (35 in. lb.)**. See Figures 11-90 and 11-91.

Figure 11-90. Torquing Base Screws.

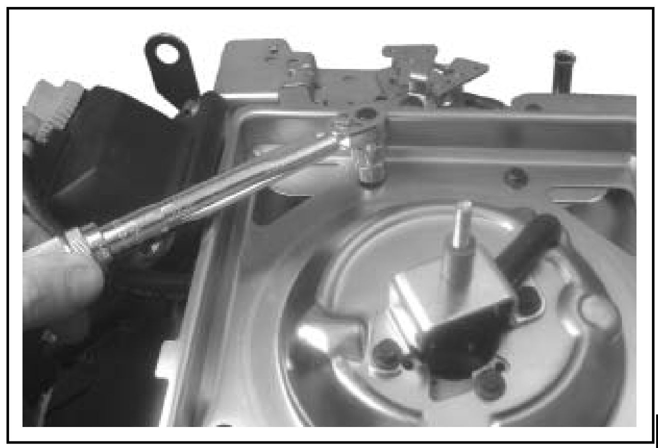


Figure 11-91. Tightening Rear Base/Bracket Screws (Some Models).

4. Install the breather hose in the hole in the bracket.

5. Install the air cleaner components as described in Section 4.

Install Muffler

1. Install the port liners (if equipped). Install the muffler and attaching hardware to the muffler bracket. Torque screws to **9.9 N·m (88 in. lb.)**.

2. Install the hex. flange nuts to the exhaust studs. Torque hex. flange nuts to **24.4. N·m (216 in. lb.)**.

Install Oil Cooler

1. Reinstall the oil cooler on the engine (if equipped). Install a new gasket between the cooler and the closure plate. Torque nipple adapter to **27 N·m (20 ft. lb.)**. See Figure 11-92.

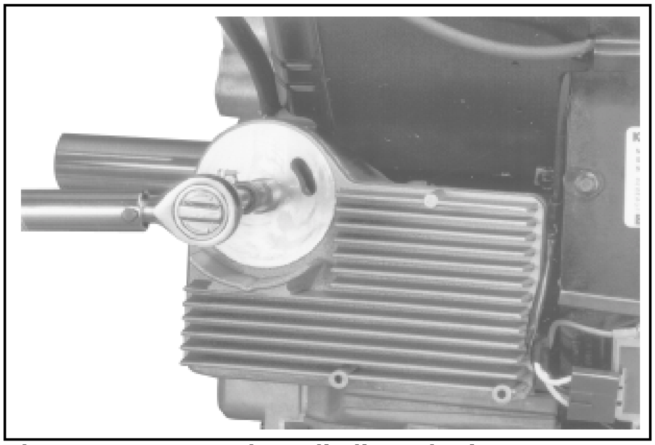


Figure 11-92. Torquing Oil Filter Nipple.

Install Oil Filter and Fill Crankcase with Oil

1. Prefill a new oil filter following the instructions in Section 6.

2. Apply a thin film of clean engine oil to the rubber gasket on the oil filter and thread the filter onto the adapter nipple. See Figure 11-93.

Figure 11-93. Installing New Oil Filter.

3. Hand tighten the filter until the rubber gasket contacts the adapter, then tighten the filter an additional 2/3-1 turn. See Figure 11-94.

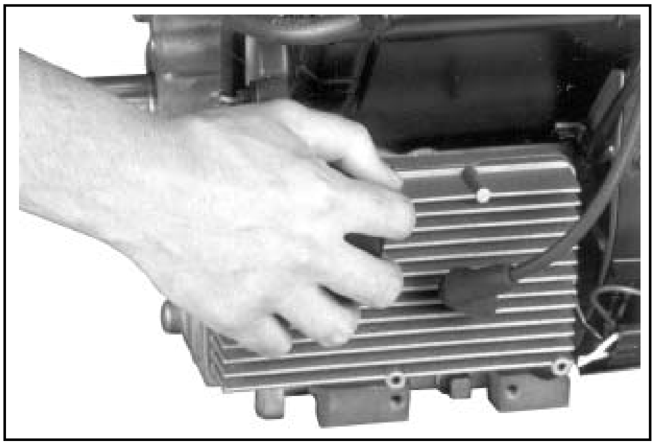


Figure 11-94. Hand Tightening Oil Filter.

4. Install the oil drain plugs. See Figure 11-95. Torque the plugs to **13.6 N·m (10 ft. lb.)**.

   NOTE: Make sure that both oil drain plugs are installed and torqued to the above specifications to prevent oil leakage.

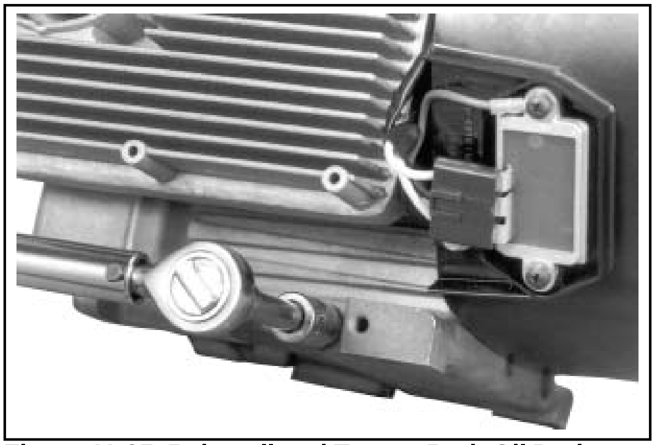


Figure 11-95. Reinstall and Torque Both Oil Drain Plugs.

5. Add oil to bring the level up to "F" mark and reinstall the dipstick. See Figure 11-96.

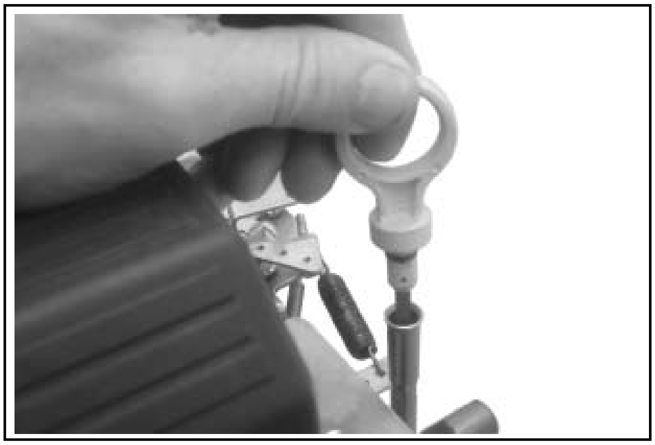


Figure 11-96. Reinstall the Dipstick in Tube.

6. Make sure the O-Ring is in place then reinstall the oil fill cap on the valve cover. See Figure 11-97.

Figure 11-97. Reinstalling Oil Fill Cap (Some Models).

Connect Spark Plug Leads

1. Connect the leads to the spark plugs. See Figure 11-98.

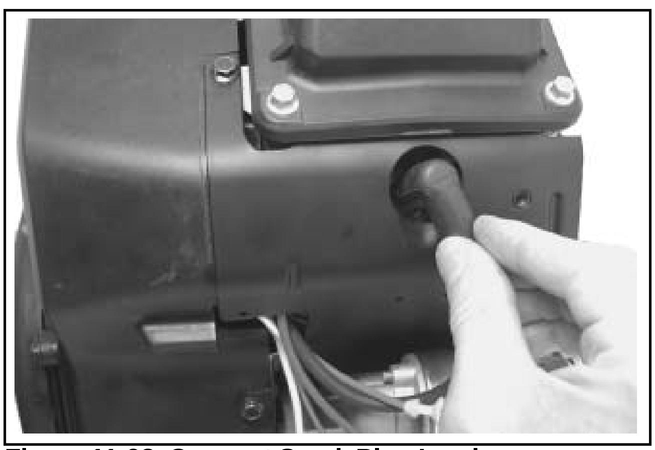


Figure 11-98. Connect Spark Plug Leads.

Prepare the Engine for Operation

The engine is now completely reassembled. Before starting or operating the engine, be sure to do the following.

1. Make sure all hardware is tightened securely.

2. Make sure the oil drain plugs, oil sentry pressure switch, and a new oil filter are installed.

3. Fill the crankcase with the correct amount, weight, and type of oil. Refer to oil recommendations and procedures in the ‘‘Safety and General Information’’ and ‘‘Lubrication System’’ sections.

4. Adjust the carburetor, idle fuel needle, or idle speed adjusting screw as necessary. Refer to Section 5, the "Fuel System and Governor".

Testing the Engine

It is recommended that the engine be operated on a test stand or bench prior to installation in the piece of equipment.

1. Set the engine up on a test stand. Install an oil pressure gauge. Start the engine and check to be certain that oil pressure (20 psi or more) is present. Run the engine at idle for 2-3 minutes, then 5-6 minutes more between idle and midrange. Adjust the carburetor mixture settings as necessary (as available).

2. Adjust the idle speed screw and high-speed stop as necessary. Make sure the maximum engine speed does not exceed 3750 RPM (no load).

Section 12
Clutch

Clutch

General
Some engines are equipped with a “wet” disc type clutch. See Figure 12-1 for exploded view of clutch.

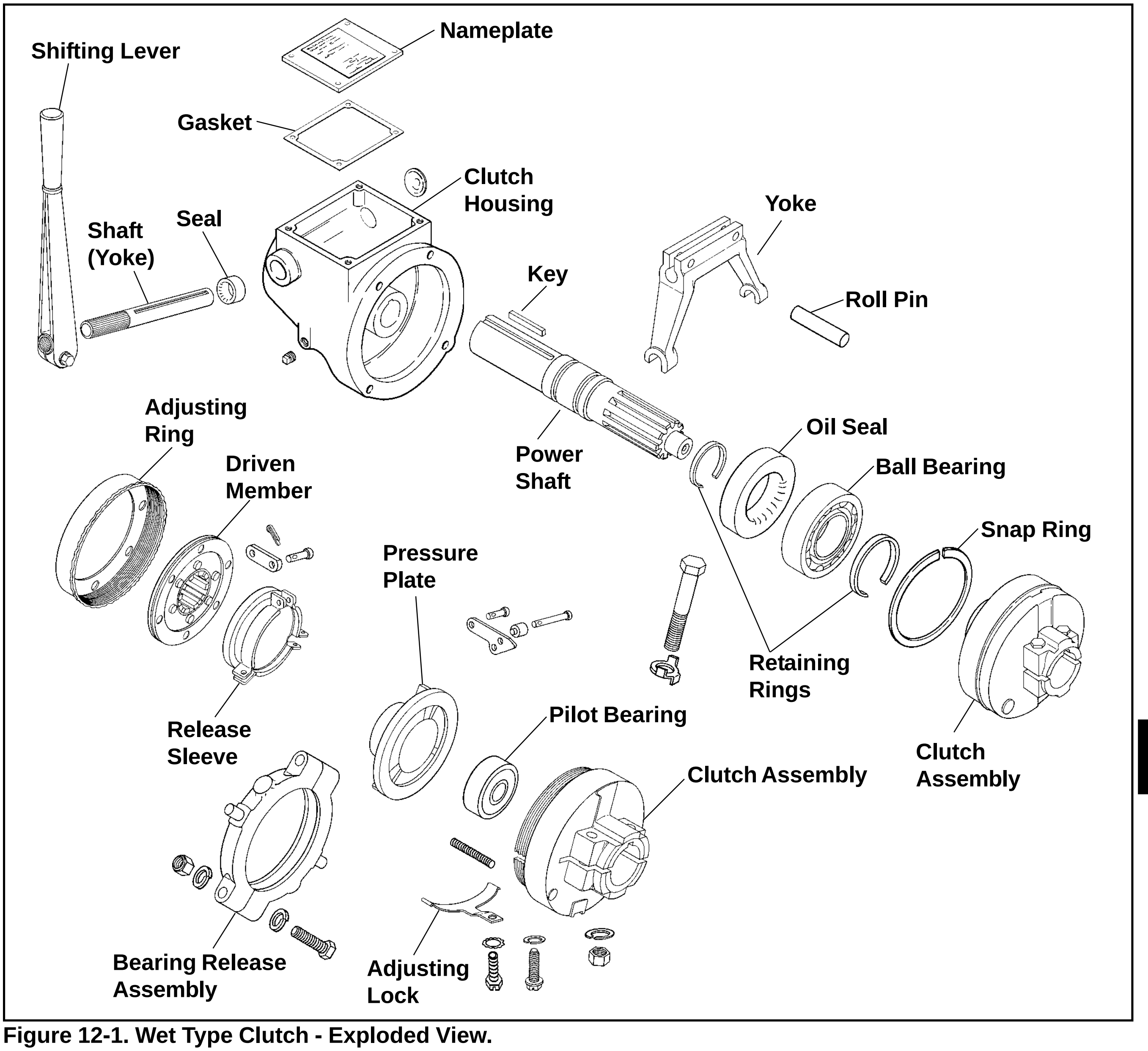


Figure 12-1. Wet Type Clutch - Exploded View.

Service
On this type, an oil “splash” type lubrication system is used. The proper oil level must be maintained to provide efficient lubrication. The oil should be changed after each 100 hours of operation. When refilling, use 0.47 L (1 pt.) of motor oil of proper viscosity. See chart below.

Temperature	SAE Viscosity
Above 10°C (50°F)	SAE 30
-17.8°C (0°F) to 10°C (50°F)	SAE 20
Below -17.8°C (0°F)	SAE 10

Adjustment
Slight readjustment may be needed after a few hours on a new clutch to accommodate normal run-in wear. Firm pressure should be required to engage clutch (40-45 pounds pull at lever handle). Readjust if clutch slips and overheats, or if clutch handle jumps out after engagement. Use the following procedure:

1. Release clutch and remove nameplate. Using a large screwdriver, turn adjusting ring clockwise, one notch at a time, until firm pressure is required to engage clutch. See Figure 12-2. Adjusting ring is spring loaded and does not have to be loosened before adjustment is made. Do not attempt to pry or force spring lock away from the ring.

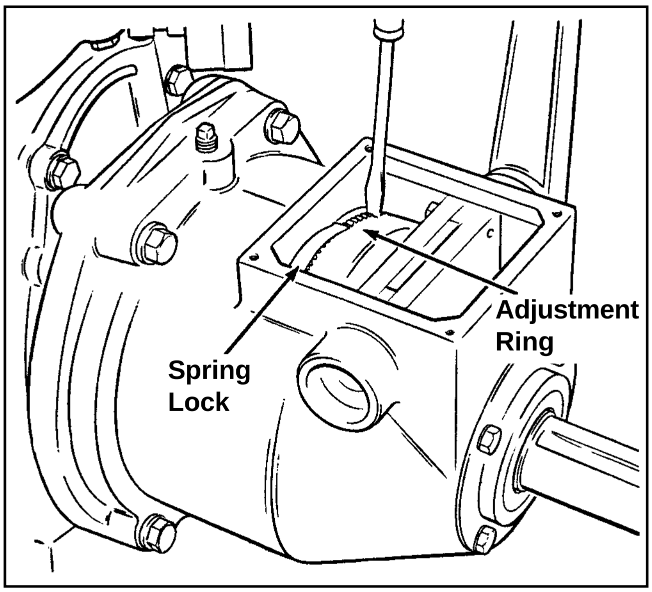


Figure 12-2. Adjusting Clutch.

2. After adjustment is made, engage clutch and check to make sure rollers go over center to lock the unit in engaged position and prevent releasing under load. If trouble persists after readjustment, clutch reconditioning is indicated.

Reconditioning
Drain the oil, remove the nameplate, and use the following procedure.

1. Remove capscrews (2) from clutch yoke and remove spacers.
2. Remove cross shaft.
3. Remove housing bolts (4) and slide housing off.
4. Loosen bolts securing clutch assembly to crankshaft, then remove locking screw.
5. Pull clutch assembly off.
6. To replace clutch, simply turn adjusting collar off and remove plate.

Reverse procedure for reassembly. Adjust and lubricate following previous instructions.

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REVISED:	6/04
MAILED:	7/04

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KOHLER engines

MEASUREMENT GUIDE

MEASUREMENT GUIDE

GENERAL GUIDELINES

This training guide is intended to be used as a teaching aid for instruction in the proper use of measuring devices as applied to the inspection of Kohler air-cooled engine components.

For complete engine teardown and inspection procedures, see the appropriate Service Manual.

All specifications and tolerances listed within this guide are subject to change without notice.

To complete the problems listed in this training guide:

1. Refer to the "Specifications And Tolerances" tables listed on pages 13 and 14. Write the Specification in the appropriate blank(s) of the exercise.

   EXAMPLE: Cylinder Head "Out Of Flatness" for M10 engine.

MAGNUM

ENGINE SPECIFICATIONS AND
ALL DIMENSIONS IN INCH

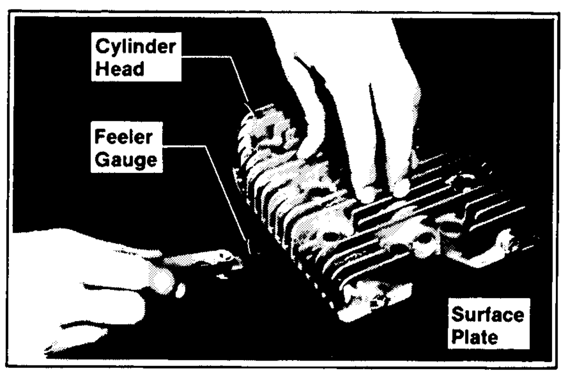
			Single		
HORSEPOWER (Maximum RPM) **Engine Model**			8 / M8	10 / M10	12
GENERAL	Bore x Stroke		2.938x2.750	3.251x2.875	3.375
	Displacement Cu. In.		18.64	23.85	29
	Max. Operating RPM		3600	3600	36
BALANCE GEAR	Shaft O.D.	New	—	.4998/.5001	.4998
		Maximum Wear Limit	—	.4996	.4
	End Play		—	.002/.010	.002
CAMSHAFT	End Play		.005/.010	.005/.010	.00
CARBURETOR	Preliminary Turns Out	Main	2	1½	1
		Idle	1¼	2¼	2
CYLINDER HD.	Max. Out of Flatness		.003	.003	.0
IGNITION	Spark Plug	Type ②	RCJ-8	RH-10	RH
		Gap	.025	.025	.0
	Module Air Gap		.012/.016	.012/.016	.012

Cylinder Head Out of Flatness Specification: .003" Max.

CYLINDER HEAD (Station No. 1)

Check the cylinder head for flatness. Use a feeler gauge and a surface plate or piece of plate glass to make this check. Clearance between the head and plate should not exceed .003" at any point. Replace the cylinder head if out of specification.

NOTE: The cylinder block should also be checked for flatness in the same manner.



Specification 0.003" MAX.

Measurement

Cylinder Head #1 0.001"

Cylinder Head #2 ______

2. Measure the component as instructed in the exercise. Write the measured value(s) in the appropriate blank(s) of the exercise.

3. Compare the measured value(s) with the Specification(s) to determine whether the component is in or out of Specification.

CYLINDER HEAD (Station No. ____)

PURPOSE: Measure the cylinder head for out of flatness.

Use a feeler gauge and a surface plate or piece of plate glass to make this check. Clearance between the head and plate should not exceed .003″ at any point. Replace the cylinder head if out of specification.

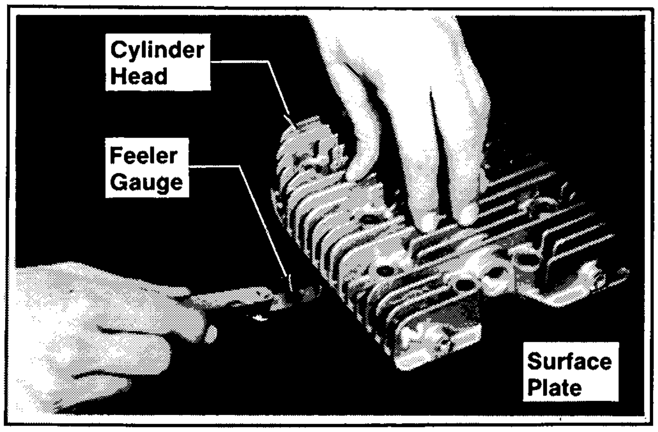
NOTE: The cylinder block should also be checked for flatness in the same manner.

Specification ________________

Measurement

Cylinder Head #1 ________________

Cylinder Head #2 ________________

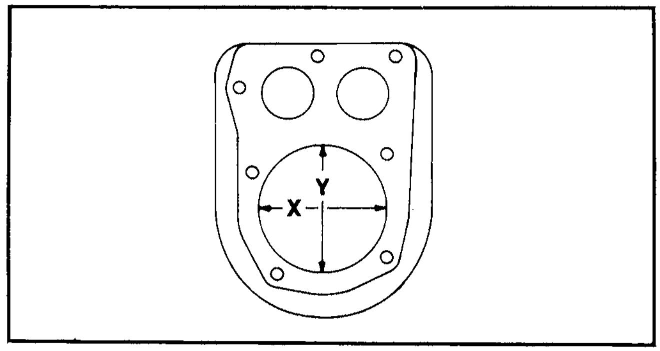


K and Magnum Series Shown

CYLINDER BORE (Station No. ____)

PURPOSE: Measure the bore for size, roundness, and taper.

Measurements can be made with an inside micrometer, telescoping gauge, or bore gauge. The measurements should be taken at three places in the piston ring travel within the cylinder: at the top, middle, and bottom. Two measurements should be taken, perpendicular to each other, at each of the three locations.



Engine Model ________________

New Diameter ________________

Out of Round Specification ________________

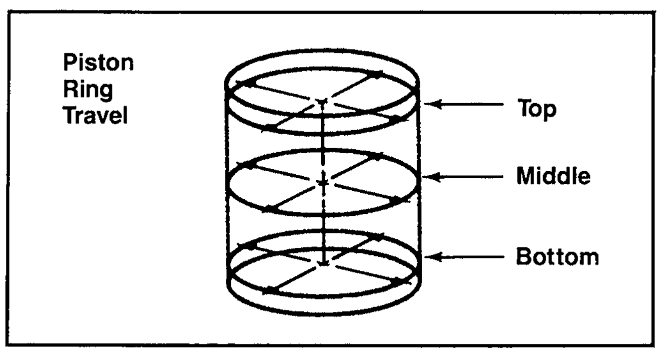
Taper Specification ________________

Bore Size

	X	Y	Out Of Round
Top	______ in.	______ in.	______ **in.**
Middle	______ in.	______ in.	______ **in.**
Bottom	______ in.	______ in.	______ **in.**
Taper	______ **in.**	______ **in.**	

Maximum Out of Round ________________ **in.**

Maximum Taper ________________ **in.**



PISTON (Station No. ____)

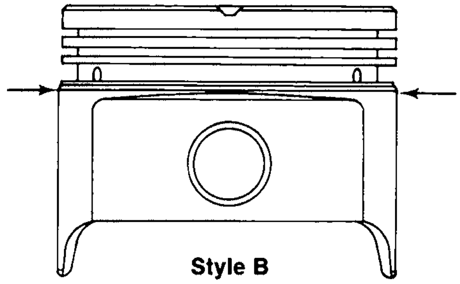
PURPOSE: To measure an engine piston to bore clearance.

To measure the piston-to-bore clearance, subtract the outside diameter of the piston from the inside diameter of the cylinder bore.

DO NOT use a feeler gauge to measure piston-to-bore clearance.

Engine Model ______________________

Bore Diameter ______________________ **Center "Y"**



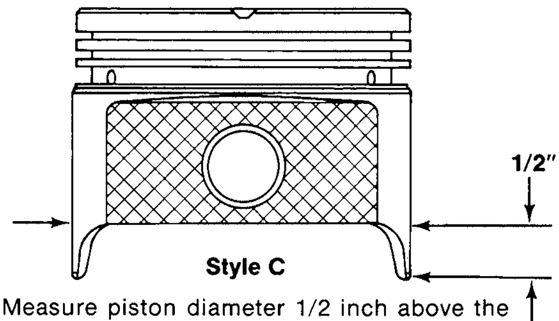
Style B

Measure piston diameter just below oil ring groove and perpendicular to the piston pin.

Piston Diameter

When measuring pistons, use a micrometer and follow the appropriate inspection methods as listed below.

	Specification	Measurement
Style A		
Style B		
Style C		
Style D		
Style E		

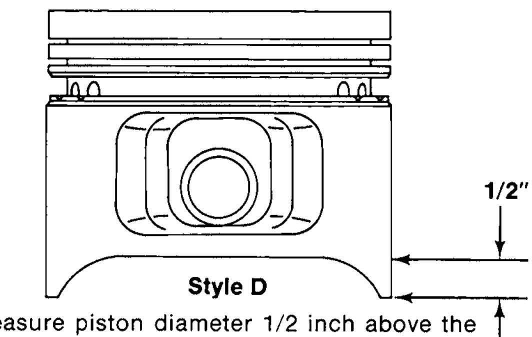


Style C

Measure piston diameter 1/2 inch above the bottom of the piston skirt and perpendicular to the piston pin.

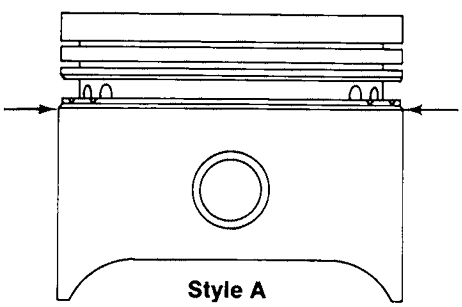
Piston-to-bore Clearance

	Specification	Measurement
Style A		
Style B		
Style C		
Style D		
Style E		



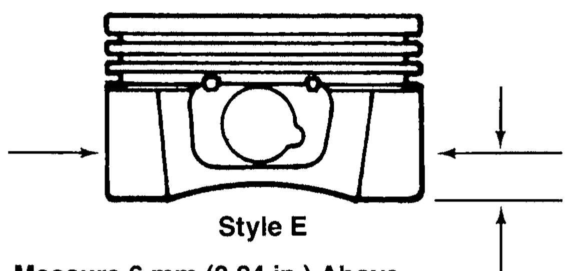
Style D

Measure piston diameter 1/2 inch above the bottom of the piston skirt and perpendicular to the piston pin.



Style A

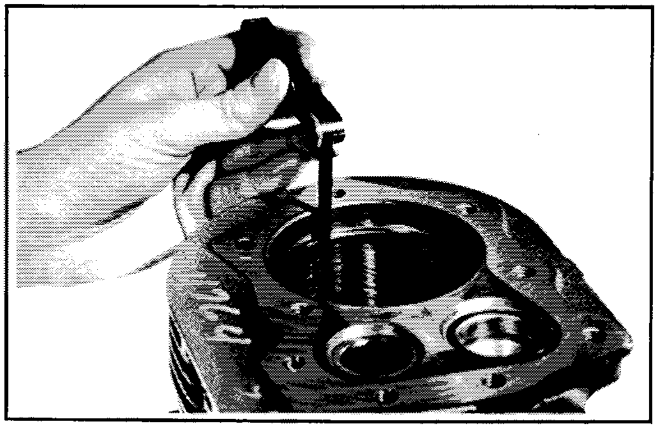
Measure piston diameter just below oil ring groove and perpendicular to the piston pin.



Style E

Measure 6 mm (0.24 in.) Above the Bottom of Piston Skirt at Right Angles to Piston Pin

PISTON RINGS (Station No. ____)



PURPOSE: To measure piston ring end gap clearance and ring size clearance.

Deglaze and clean the cylinder bore prior to checking the end gaps of new rings. Place the rings each in turn in its running area in the cylinder bore. Use a feeler gauge and check the end gap. In .010 and .030 service ring sets, the oil ring may have end gaps as high as .060".

Engine Model ____________________

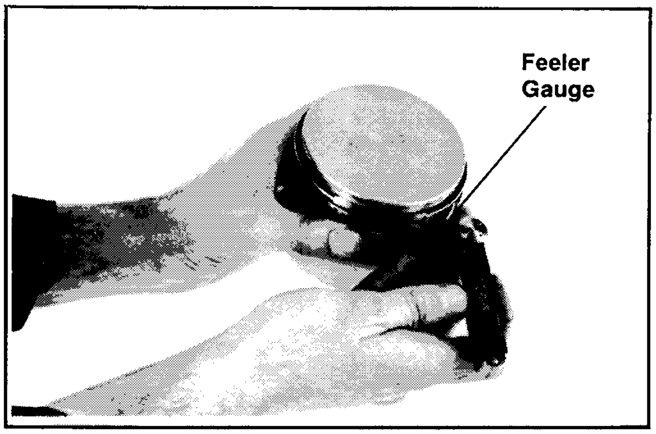
Specification (New Bore) ____________________

Specification (Used Bore) ____________________

Measurement Top ____________________

Center ____________________

Oil ____________________



Ring Side Clearance

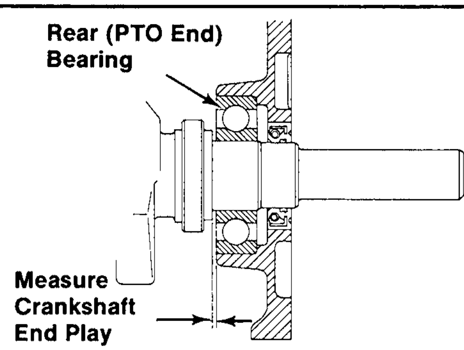
Use a feeler gauge to check the side clearance of each ring after installation.

Engine Model ____________________

Specification ____________________

Measurement ____________________

CRANKSHAFT END PLAY (Station No. ____)



PURPOSE: To measure crankshaft end play.

Crankshaft end play is measured with a feeler gauge between the inner race of the bearing and the shoulder on the crankshaft. If the end play is not within tolerance, remove the bearing plate and add or subtract gaskets to achieve proper clearance.

Engine Model ____________________

Specification ____________________

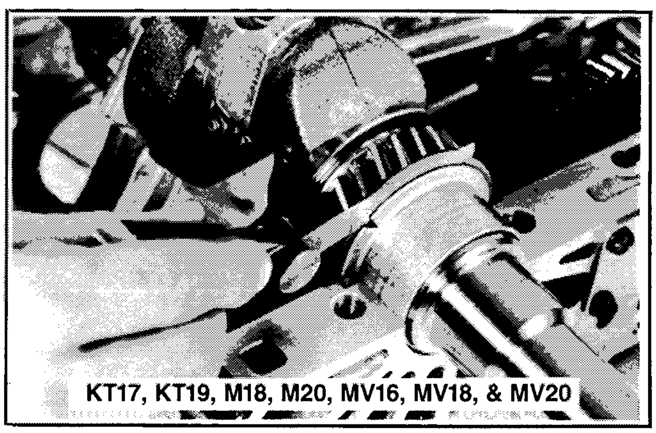
Measurement ____________________

Check crankshaft end play with a feeler gauge. Use the #1 crankcase half to check the end play. Then add the correct thrust washer to bring clearance within specification. Three sizes of thrust washers are available: .123/.126, .130/.133, and .138/.141.

Engine Model ____________________

Specification ____________________

Measurement ____________________



CRANKPIN (Station No. ____)

PURPOSE: To measure the crankpin for size, roundness, and taper.

All measurements should be taken perpendicular to each other along the crankpin.

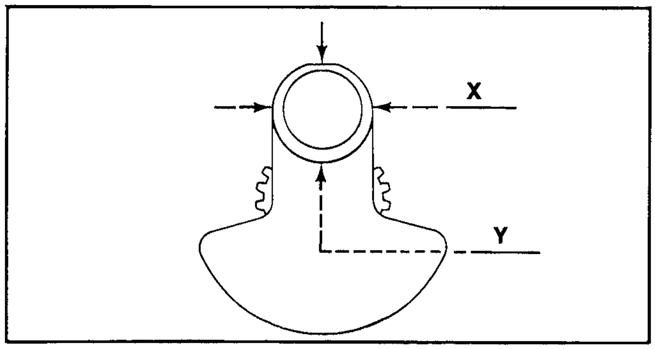
Engine Model ______________________

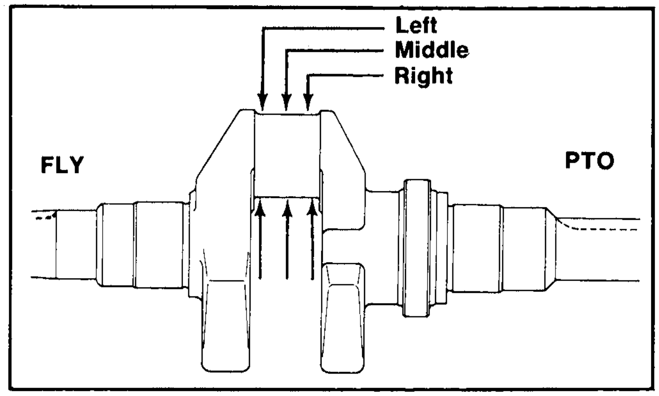
New Diameter ______________________

Maximum Wear Limit ______________________

Out of Round Specification ______________________

Taper Specification ______________________





Crankpin Measurements

	X	Y	Out of Round
Left	______ in.	______ in.	______ in.
Middle	______ in.	______ in.	______ in.
Right	______ in.	______ in.	______ in.

Taper ______ **in.** ______ **in.**

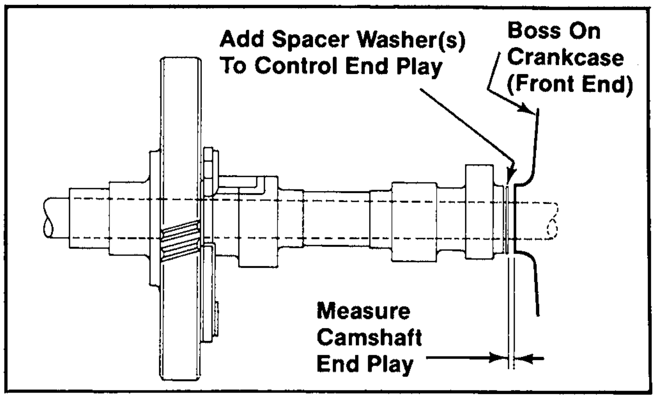
Maximum Out of Round ______________ **in.**

Maximum Taper ______________ **in.**

CAMSHAFT (Station No. ____)

PURPOSE: To measure the camshaft end play.

To measure use a feeler gauge and add or subtract washers to obtain proper end play.

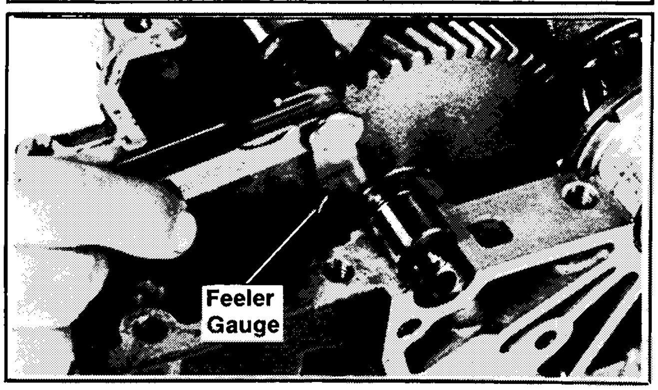


Single Cylinder: K and Magnum Series

Engine Model ______________________

Specification ______________________

Measurement ______________________



Single Cylinder: Command Series

Engine Model ______________________

Specification ______________________

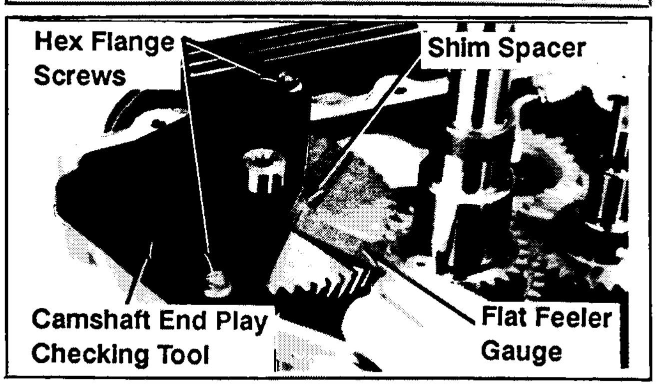
Measurement ______________________

Twin Cylinder: K and Magnum Series

Engine Model ______________________

Specification ______________________

Measurement ______________________



NOTE: Check end play in #1 crankcase half.

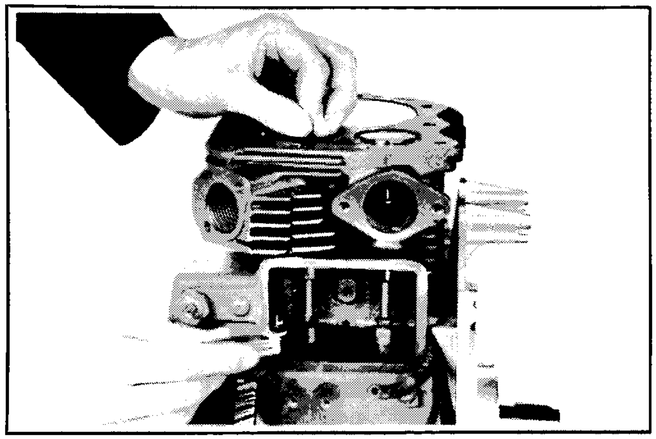
VALVES (Station No. ____)

PURPOSE: To measure intake and exhaust valve tappet clearance.

Valve clearance should be checked cold. Rotate the camshaft to a position where the cam has no effect on the tappet (TDC on compression stroke). Hold the valve firmly on the seat, and check the clearance between the valve stem and tappet with a feeler gauge. On **K91, K141, K161, K181, M8, KT17, KT19, M18, M20, MV16, and MV18** engines with insufficient valve clearances, the valves must be removed and ends ground until proper clearance is obtained. Reface the valve, grind the seat, or replace the valve if the clearance is excessive.

NOTE: **Make certain the ends are ground square and all burrs removed.**

On **K241, K301, K321, K341, M10, M12, M14, M16, and K532/582** engines, the tappets are adjustable.



K and Magnum Series Shown

Engine Model ____________________

Exhaust

Specification ____________________

Measurement ____________________

Intake

Specification ____________________

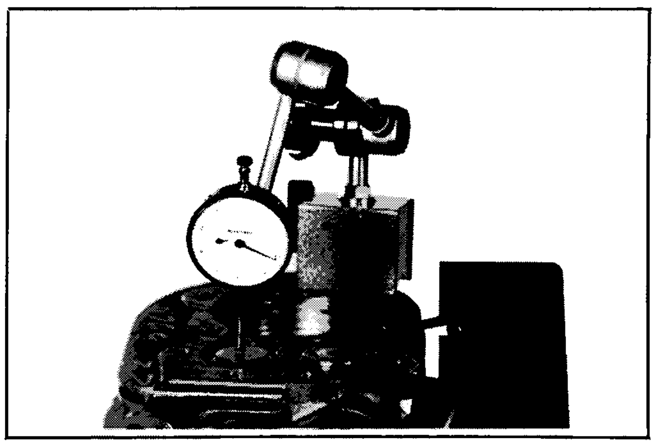
Measurement ____________________

AUTOMATIC COMPRESSION RELEASE (Station No. ____)

PURPOSE: To measure automatic compression lift.

On Kohler single-cylinder engines with Serial 9006117 or earlier, the ACR can be checked and reset. ACR is set according to the amount of valve lift on the exhaust valve—check lift as follows:

1. Check valve tappet clearances, and adjust as necessary to specification.
2. Remove the cylinder head, and turn the engine over by hand until you reach BDC or the intake stroke. (Intake valve will be closing.)
3. Mount a dial indicator on the top of the exhaust valve and set at 0.
4. Slowly turn the flywheel clockwise, and watch the dial indicator. When the piston is about 2/3 of the way up the cylinder, the exhaust valve should open for ACR.



K and Magnum Series Shown

Specification	Approx. Lift
Serial No. 9006117 or earlier	= .031-.042
Serial No. 9006118 and higher*	= .015-.031

***Non-Adjustable**

Engine Model ____________________

Serial Number ____________________

Measurement ____________________

VALVE GUIDE TO VALVE STEM CLEARANCE K AND MAGNUM SERIES (Station No. ____)

PURPOSE: To measure valve guide to valve stem clearance.

Thoroughly clean the valve guide with a reamer and, using a split-ball gauge, measure the ID diameter. Then, using an outside micrometer, measure the diameter of the valve stem at several points on the stem where it moves in the guide. Use the largest stem diameter to calculate the clearance. If the clearance exceeds the specified limits, determine whether the valve stem or the guide is responsible for the excessive clearance. If the valve stem diameter is within specifications, replace the valve guide.

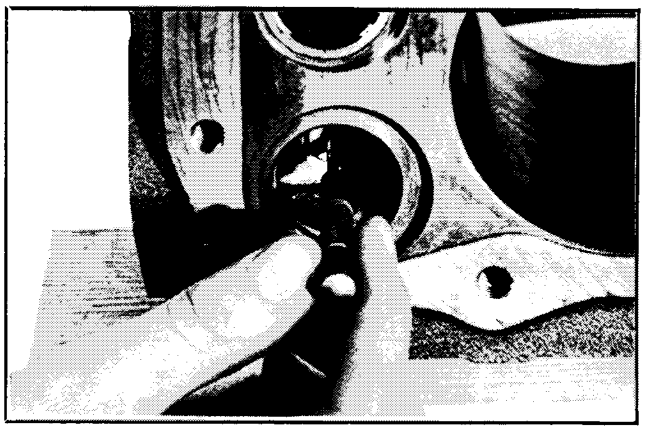
Engine Model ____________________

Specification

	Intake	Exhaust
Guide I.D. Max. Wear Limit	______	______
Valve stem Min. Outside Diameter	______	______

A. Valve Guide

	Intake	Exhaust
Measurement	______	______



Measuring Valve Guide I.D.

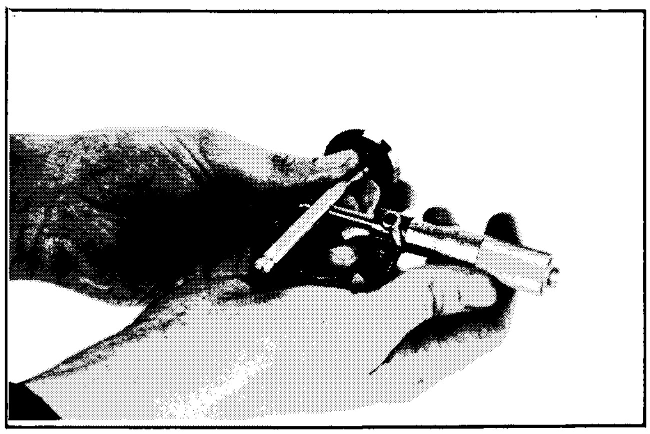
B. Valve Stem

	Intake	Exhaust
Measurement	______	______

C. Stem-To-Guide Clearance

	Intake	Exhaust
Measurement	______	______

(A - B = C)



Measuring Valve Stem O.D.

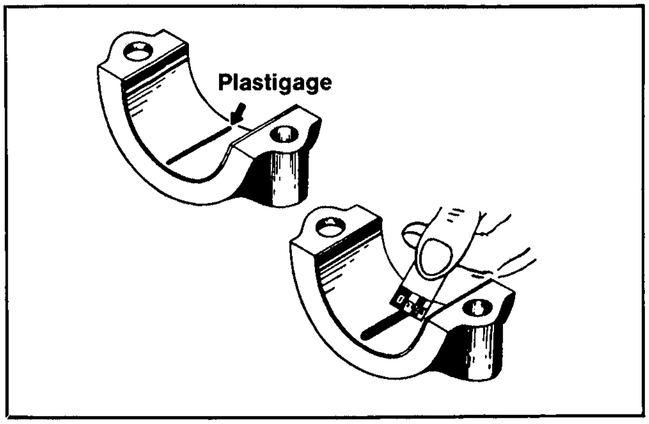
CONNECTING ROD–CRANKPIN CLEARANCE (Station No. ____)

PURPOSE: To measure the connecting rod-to-crankpin clearance.

Install the connecting rod(s) on the crankshaft crankpin. Torque the connecting rod fasteners as shown in the appropriate tables below.

Loosen the fasteners and remove the rod cap. Insert plastigage, replace the rod cap, and again torque fasteners to specifications listed below.

Loosen the fasteners, remove the rod cap, and check the clearance indicated by the plastigage.



Engine Model ____________________

Specification ____________________

Measurement ____________________

Torque Value - Capscrew*

Engine Model		Bolt Size (Inches)	Final Torque (In.-Lbs.)	Overtorque (In.-Lbs.)
Single Cylinder	K91	1/4	140	168
	K141, K161, K181	5/16	200	240
	K241, K301, K321, K341, K361	3/8	285	342
Twin Cylinder	KT17, KT19, KT21	5/16	200	240
	K482, K532, K582	5/16 3/8	200 300	240 360

*NOTE: Torque capscrews to 20% over the final value. Loosen the capscrews so torque is below the final value—do not leave screws overtorqued. Retorque screws to the final value.

Torque Value - Posi-Lock

	Engine Model		New (In. Lbs.)	Used (In. Lbs.)
Posi-Lock[1]	Single Cylinder	M8, K181	140	100
		M10, M12, M14, M16, K241, K301, K321, K341	260	200
		C5	80	80
		CV12.5/CV14	200	200
	Twin Cylinder	KT17, KT19, M18, M20, MV16, MV18, MV20	140	100

[1]DO NOT overtorque—loosen—and retorque the hex nuts on Posi-Lock connecting rods. Torque the hex nuts, in increments, directly to the values specified in the table.

NEW - Component directly from stock.

USED - Component that was in a running engine.

CARBURETOR (Station No. ____)

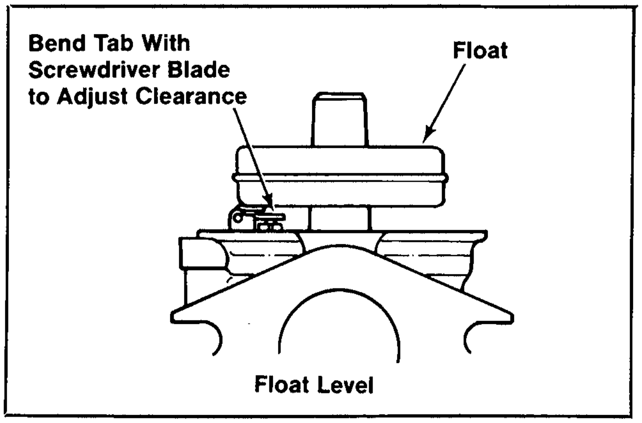
Float Level

PURPOSE: To measure the carburetor float level.

Invert the carburetor (with the bowl removed), and ensure the float tab is resting lightly against the needle in its seat. Measure the clearance between the machined surface of the casting and free end of the float. Adjust as necessary to specification by bending the float tab with a small screwdriver.

Specification
Float Level = 9/64-13/64 in.

Measurement
Float Level ____________________



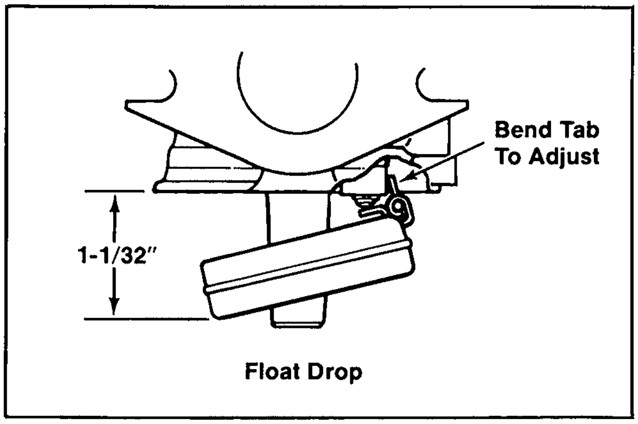
Float Level

Float Drop

To set float drop: turn the carburetor over to its normal operating position and allow float to drop to its lowest level. The float drop should be limited to 1-1/32" between the machined surface of body and the bottom of the free end of float. Bend the float tab with a small screwdriver to adjust.

Specification
Float Level = 1-1/32 in. Maximum

Measurement
Float Level ____________________

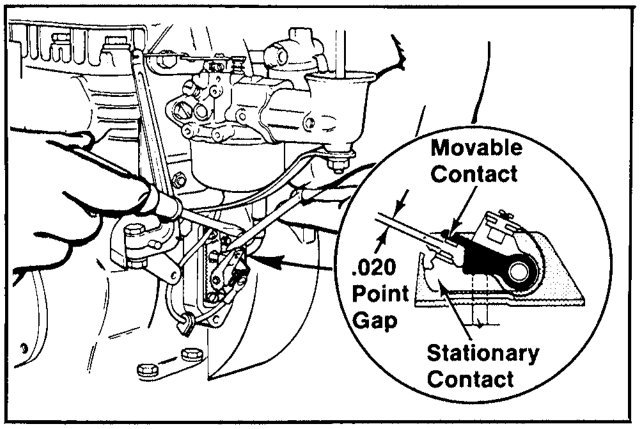


Float Drop

BREAKER POINTS (Station No. ____)

PURPOSE: To measure the breaker point gap.

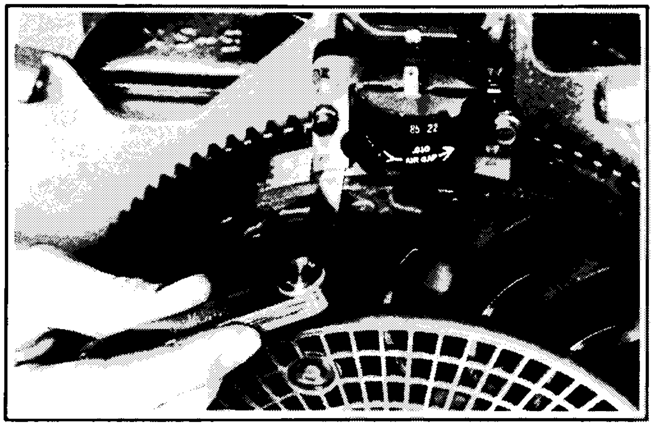
Disconnect the spark plug lead and remove the breaker point cover. Rotate the engine by hand in the direction of normal rotation (clockwise from flywheel end). Points should begin to open as the "S" mark appears in the center of the timing sight hole. Continue rotating until points reach maximum opening. Measure the gap with a feeler gauge and adjust if necessary. To adjust, loosen point gap adjustment screw and adjust to specification. Tighten screw after proper gap has been reached.



Specification ____________________

Measurement ____________________

IGNITION MODULE (Station No. ____)



PURPOSE: To measure ignition module air gap.

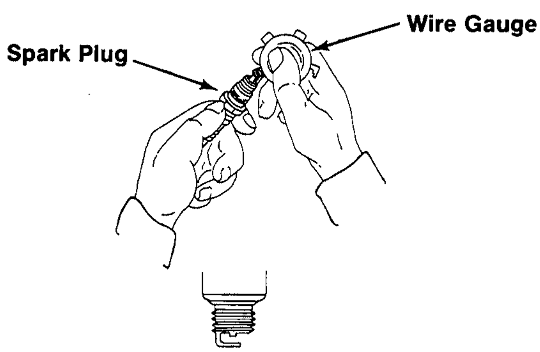
When checking the flywheel magnet-to-module air gap, insert a flat feeler gauge between the flywheel magnet and ignition module legs.

Specifications

Models M8, M10, M12, M14, and M16—.012″-.016″
Models M18, M20, MV16, MV18, and MV20—.008″-.012″

Measurement ____________________

SPARK PLUG (Station No. ____)



Checking Plug Gap

PURPOSE: To measure spark plug gap.

Remove the spark plug, check the condition, and reset the gap to specification using a feeler gauge or wire gauge.

Engine Model ____________________

Ignition System ____________________

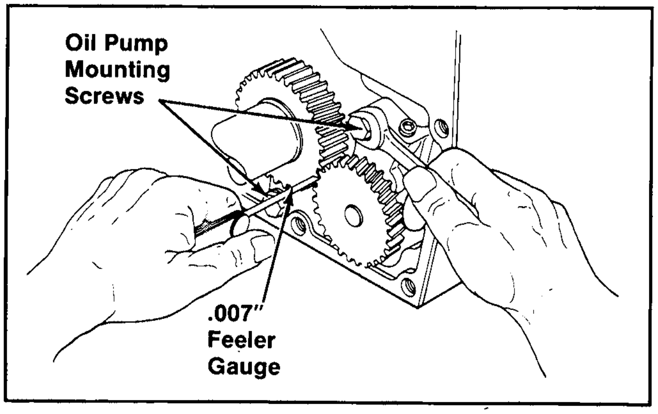
Specification ____________________

Measurement ____________________

OIL PUMP (K532/K582) (Station No. ____)

PURPOSE: To measure oil pump crankshaft drive gear backlash.

Use a .007" tapered feeler gauge to check oil pump backlash. Mount the pump to the engine, but do not fully tighten the mounting screws, and check the backlash. When backlash is within specification, tighten the mounting screws. Recheck the backlash at two other points on the gear (120° apart) to determine if the backlash, through the gear circumference, falls within the specified range. Readjust, as necessary, until all three points fall within range.



Specification ____________________

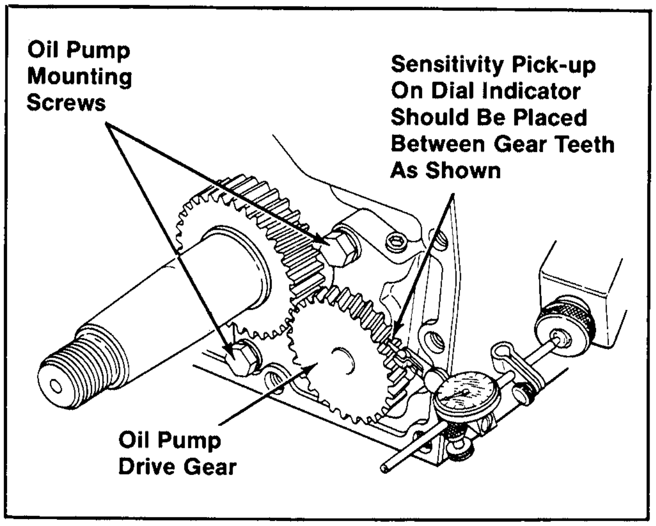
Measurement

Point A ____________________

Point B ____________________

Point C ____________________

A dial indicator can also be used to check oil pump backlash. Mount the pump to the engine, but do not fully tighten the mounting screws. Mount a dial indicator on the engine so the sensing arm rests against one of the pump gear teeth. Zero the indicator, and measure the pump gear backlash. Adjust the pump body until backlash is within specifications. Then tighten the mounting screws. Recheck the backlash at two other points on the gear (120° apart) to determine if the backlash, through the gear circumference, falls within the specified range. Readjust, as necessary, until all three points fall within range.



Specification ____________________

Measurement

Point A ____________________

Point B ____________________

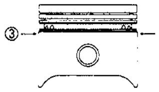
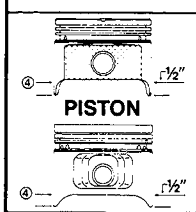
Point C ____________________

MAGNUM

ENGINE SPECIFICATIONS AND TOLERANCES

ALL DIMENSIONS IN INCHES

KOHLER engines

			Single Cylinder					Twin Cylinder Aluminum Crankcase	
HORSEPOWER (Maximum RPM) / Engine Model			8 / M8	10 / M10	12 / M12	14 / M14	16 / M16	16, 18 / M18 MV16, MV18	20 / M20 MV20
GENERAL	Bore x Stroke		2.938x2.750	3.251x2.875	3.375x3.250	3.500x3.250	3.750x3.250	3.125x2.750	3.125x3.062
GENERAL	Displacement Cu. In.		18.64	23.85	29.07	31.27	35.90	42.18	46.98
GENERAL	Max. Operating RPM		3600	3600	3600	3600	3600	3600	3600
BALANCE GEAR	Shaft O.D.	New	—	.4998/.5001	.4998/.5001	.4998/.5001	.4998/.5001	—	—
BALANCE GEAR	Shaft O.D.	Maximum Wear Limit	—	.4996	.4996	.4996	.4996	—	—
BALANCE GEAR	End Play		—	.002/.010	.002/.010	.002/.010	.002/.010	—	—
CAMSHAFT	End Play		.005/.010	.005/.010	.005/.010	.005/.010	.005/.010	.003/.013	.003/.013
CONNECTING ROD	Running Clearance	Rod To Crank-Pin (New)	.001/.002	.001/.002	.001/.002	.001/.002	.001/.002	.0012/.0024	.0012/.0024
CONNECTING ROD	Running Clearance	Rod To Crank-Pin Wear Limit	.0025	.0025	.0025	.0025	.0025	.0029	.0029
CONNECTING ROD	Running Clearance	Rod To Piston Pin (New)	.0006/.0011	.0003/.0008	.0003/.0008	.0003/.0008	.0003/.0008	.0006/.0011	.0006/.0011
CONNECTING ROD	Small End I.D. (New)		.6255/.6258	.8596/.8599	.8757/.8760	.8757/.8760	.8757/.8760	.6255/.6258	.7507/.7510
CRANKSHAFT	MAINS: PTO & Flywheel End O.D.	New	1.1811/1.1814	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.7412/1.7422	1.7412/1.7422
CRANKSHAFT	MAINS: PTO & Flywheel End O.D.	Maximum Wear Limit	1.1811	1.5745	1.5745	1.5745	1.5745	1.7407	1.7407
CRANKSHAFT	MAINS: Max. Out of Round (Sleeve)		—	—	—	—	—	.0005	.0005
CRANKSHAFT	MAINS: Max. Taper (Sleeve)		—	—	—	—	—	.001	.001
CRANKSHAFT	MAINS: Running Clearance (Sleeve)	Maximum New	—	—	—	—	—	.0049	.0049
CRANKSHAFT	MAINS: Running Clearance (Sleeve)	Wear Limit ①	—	—	—	—	—	.0059	.0059
CRANKSHAFT	MAINS: New Sleeve Bearing I.D. Installed		—	—	—	—	—	1.7439/1.7461	1.7439/1.7461
CRANKSHAFT	CRANKPIN: New		1.1860/1.1855	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.3738/1.3733	1.4998/1.4993
CRANKSHAFT	CRANKPIN: Max. Wear Limit		1.1850	1.4990	1.4990	1.4990	1.4990	1.3728	1.4988
CRANKSHAFT	CRANKPIN: Max. Out of Round		.0005	.0005	.0005	.0005	.0005	.0005	.0005
CRANKSHAFT	CRANKPIN: Max. Taper		.001	.001	.001	.001	.001	.001	.001
CRANKSHAFT	End Play		.002/.023	.003/.020	.003/.020	.003/.020	.003/.020	.002/.014	.002/.014
CYLINDER BORE	Inside Diameter	New	2.9380/2.9370	3.2515/3.2505	3.3755/3.3745	3.5005/3.4995	3.7505/3.7495	3.1255/3.1245	3.1255/3.1245
CYLINDER BORE	Inside Diameter	Maximum Wear Limit	2.941	3.254	3.378	3.503	3.753	3.128	3.128
CYLINDER BORE	Max. Out of Round		.003	.003	.003	.003	.003	.002	.002
CYLINDER BORE	Max. Taper		.003	.002	.002	.002	.002	.0015	.0015
CYLINDER HD.	Max. Out of Flatness		.003	.003	.003	.003	.003	.003	.003
IGNITION	Spark Plug	Type ②	RCJ-8	RH-10	RH-10	RH-10	RH-10	RV15YC	RV15YC
IGNITION	Spark Plug	Gap	.025	.025	.025	.025	.025	.025	.025
IGNITION	Module Air Gap		.012/.016	.012/.016	.012/.016	.012/.016	.012/.016	.008/.012	.008/.012
PISTON 	Service Replacement Sizes		← .003 — .010 — .020 — .030 →						
PISTON	Thrust Face O.D. ③	New	2.9297/2.9281	3.2432/3.2413	3.368/3.365	3.4941/3.4925	—	—	—
PISTON	Thrust Face O.D. ③	Maximum Wear Limit	2.925	3.238	3.363	3.491	—	—	—
PISTON	Thrust Face To Bore Clearance (New) ① ③		.007/.010	.007/.010	.007/.010	.007/.010	—	—	—
PISTON	Ring End Gap	New Bore	.007/.017	.010/.020	.010/.020	.010/.020	—	—	—
PISTON	Ring End Gap	Used Bore (Max.)	.027	.030	.030	.030	—	—	—
PISTON	Max. Ring Side Clearance		.006	.006	.006	.006	—	—	—
PISTON 	Service Replacement Sizes		← .003 — .010 — .020 — .030 →						
PISTON	Thrust Face O.D. ④	New	2.9329/2.9336	—	3.3700/3.3693	3.4945/3.4938	3.7465/3.7455	3.1210/3.1203	3.1215/3.1208
PISTON	Thrust Face O.D. ④	Maximum Wear Limit	2.9312	—	3.3673	3.4918	3.7435	3.1181	3.1186
PISTON	Thrust Face To Bore Clearance (New) ① ④		.0034/.0051	—	.0045/.0062	.0050/.0067	.0030/.0050	.0035/.0052	.0030/.0047
PISTON	Ring End Gap	New Bore ⑤	.010/.023	—	.010/.020	.010/.020	.010/.020	.010/.023	.010/.023
PISTON	Ring End Gap	Used Bore ⑤ (Max.)	.032	—	.030	.030	.030	.032	.032
PISTON	Max. Ring Side Clearance		.006	—	.006	.006	.006	.006	.006
PISTON PIN	Outside Diameter		.6247/.6249	.8591/.8593	.8752/.8754	.8752/.8754	.8752/.8754	.6247/.6249	.7499/.7501
VALVES	Guide Reamer Size		.3125	.3125	.3125	.3125	.3125	.3125	.3125
VALVES	Tappet Clearance (Cold)	Intake	.006/.008	.008/.010	.008/.010	.008/.010	.008/.010	.003/.006	.003/.006
VALVES	Tappet Clearance (Cold)	Exhaust	.017/.019	.017/.019	.017/.019	.017/.019	.017/.019	.011/.014 ⑥	.011/.014 ⑥
VALVES	Minimum Lift (Zero Lash)	Intake	.2718	.318	.318	.318	.318	.274	.274
VALVES	Minimum Lift (Zero Lash)	Exhaust	.2482	.318	.318	.318	.318	.274	.274
VALVES	Minimum Valve Stem O.D.	Intake	.3103	.3103	.3103	.3103	.3103	.3103	.3103
VALVES	Minimum Valve Stem O.D.	Exhaust	.3074	.3074	.3074	.3074	.3074	.3088	.3088
VALVES	Nominal Angle Valve Seat		45°	45°	45°	45°	45°	45°	45°
VALVES	Guide I.D. Maximum Wear Limit ①	Intake	.006	.006	.006	.006	.006	.005	.005
VALVES	Guide I.D. Maximum Wear Limit ①	Exhaust	.008	.008	.008	.008	.008	.007	.007

① Maximum limits combination of I.D. and O.D. measurements.
② Champion spark plugs or equivalent.
③ Measure just below oil ring and at right angles to piston pin.
④ Measure ½" above bottom of piston skirt.
⑤ Top and center compression rings.
⑥ Prior to Serial #1816501776 .016/.019

Litho in U.S.A. Issued 4/86 Revised 9/88

ENGINE DIVISION KOHLER CO KOHLER, WISCONSIN 53044 TP-2276-A

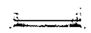
K Series

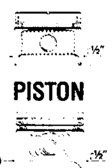
KOHLER engines

ENGINE SPECIFICATIONS AND TOLERANCES

ALL DIMENSIONS IN INCHES

			Single Cylinder							Twin Cylinder		
										Aluminum Crankcase		Cast Iron
HORSEPOWER (Maximum RPM) / Engine Model			4 / K91	7 / K161	8 / K181	10 / K241	12 / K301	14 / K321	16 / K341	17 / KT17	19 / KT19	23 / K582
GENERAL	Bore x Stroke		2.375x2.000	2.938x2.500	2.938x2.750	3.251x2.875	3.375x3.250	3.500x3.250	3.750x3.250	3.125x2.750	3.125x3.062	3.500x3.000
	Displacement Cu. In.		8.86	16.94	18.64	23.85	29.07	31.27	35.90	42.18	46.98	57.73
	Max. Operating RPM		4000	3600	3600	3600	3600	3600	3600	3600	3600	3600
BALANCE GEAR	Shaft O.D.	New	—	—	—	.4998/.5001	.4998/.5001	.4998/.5001	.4998/.5001	—	—	—
		Maximum Wear Limit	—	—	—	.4996	.4996	.4996	.4996	—	—	—
	End Play		—	—	—	.002/.010	.002/.010	.002/.010	.002/.010	—	—	—
CAMSHAFT	Sleeve I.D. Installed		—	—	—	—	—	—	—	—	—	Rear 1.251/1.252 Front 1.876/1.877
	End Play		.005/.020	.005/.010	.005/.010	.005/.010	.005/.010	.005/.010	.005/.010	.003/.013	.003/.013	.003/.024
CONNECTING ROD	Running Clearance	Rod To Crank-Pin (New)	.001/.0025	.001/.002	.001/.002	.001/.002	.001/.002	.001/.002	.001/.002	.0012/.0024	.0012/.0024	.001/.002
		Rod To Crank-Pin Wear Limit	.003	.0025	.0025	.0025	.0025	.0025	.0025	.0029	.0029	.0025
		Rod To Piston Pin (New)	.0007/.0008	.0006/.0011	.0006/.0011	.0003/.0008	.0003/.0008	.0003/.0008	.0003/.0008	.0006/.0011	.0006/.0011	.0003/.0008
	Small End I.D. (New)		.5630/.5633	.6255/.6258	.6255/.6258	.8596/.8599	.8757/.8760	.8757/.8760	.8757/.8760	.6255/.6258	.7507/.7510	.8757/.8760
CRANKSHAFT — MAINS	PTO & Flywheel End O.D.	New	.9841/.9844	1.1811/1.1814	1.1811/1.1814	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.7412/1.7422②	1.7412/1.7422②	1.7495/1.7500③
		Maximum Wear Limit	.9841	1.1811	1.1811	1.5745	1.5745	1.5745	1.5745	1.7407②	1.7407②	1.7490③
	Max. Out of Round (Sleeve)		—	—	—	—	—	—	—	.0005	.0005	.0005
	Max. Taper (Sleeve)		—	—	—	—	—	—	—	.001	.001	.001
	Running Clearance (Sleeve)	Maximum New	—	—	—	—	—	—	—	.0049	.0049	.004
		Wear Limit ①	—	—	—	—	—	—	—	.0059	.0059	.005
	New Sleeve Bearing I.D. Installed		—	—	—	—	—	—	—	1.7439/1.7461	1.7439/1.7461	1.7515/1.7535
CRANKSHAFT — CRANKPIN	New		.9360/.9355	1.1860/1.1855	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.3738/1.3733	1.4998/1.4993④	1.6250/1.6245
	Max. Wear Limit		.9350	1.1850	1.1850	1.4990	1.4990	1.4990	1.4990	1.3728	1.4988④	1.6240
	Max. Out of Round		.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005	.0005
	Max. Taper		.001	.001	.001	.001	.001	.001	.001	.001	.001	.001
CRANKSHAFT	End Play		.004/.023	.002/.023	.002/.023	.003/.020	.003/.020	.003/.020	.003/.020	.002/.014⑤	.002/.014⑤	.004/.010
CYLINDER BORE	Inside Diameter	New	2.3755/2.3745	2.9380/2.9370	2.9380/2.9370	3.2515/3.2505	3.3755/3.3745	3.5005/3.4995	3.7505/3.7495	3.1255/3.1245	3.1255/3.1245	3.5005/3.4995
		Maximum Wear Limit	2.378	2.941	2.941	3.254	3.378	3.503	3.753	3.128	3.128	3.503
	Max. Out of Round		.003	.003	.003	.003	.003	.003	.003	.002	.002	.003
	Max. Taper		.003	.003	.003	.002	.002	.002	.002	.0015	.0015	.002
CYLINDER HD.	Max. Out of Flatness		.003	.003	.003	.003	.003	.003	.003	.003	.003	.003
IGNITION	Spark Plug Type & Gap	Type⑥	RCJ-8	RCJ-8	RCJ-8	RH-10	RH-10	RH-10	RH-10	RV15YC	RV15YC	RH-10
		Battery	.025	.025	.025	.035	.035	.035	.035	.025	.025	.025
		Magneto	.025	.025	.025	.025	.025	.025	.025	—	—	—
		Gaseous Fuels	.018	.018	.018	.018	.018	.018	.018	.018	.018	.018
	Nominal Point Gap		.020	.020	.020	.020	.020	.020	.020	.020	.020	.020
PISTON ⑦	Service Replacement Sizes		.003 — .010 — .020 — .030									
	Thrust Face O.D.⑦	New	2.371/2.369	2.9297/2.9281	2.9297/2.9281	3.2432/3.2413	3.368/3.365	3.4941/3.4925	3.7425/3.7410⑨	3.118/3.117	3.121/3.120	3.4941/3.4925
		Maximum Wear Limit	2.366	2.925	2.925	3.238	3.363	3.491	3.738⑨	3.113	3.113	3.491
	Thrust Face To Bore Clearance (New)①⑦		.0035/.006	.007/.010	.007/.010	.007/.010	.007/.010	.007/.010	.007/.010⑨	.0065/.0085	.0035/.0055	.007/.010
	Ring End Gap	New Bore	.007/.017	.007/.017	.007/.017	.010/.020	.010/.020	.010/.020	.010/.020	.010/.020	.010/.020	.010/.020
		Used Bore (Max.)	.027	.027	.027	.030	.030	.030	.030	.030	.030	.030
	Max. Ring Side Clearance		.006	.006	.006	.006	.006	.006	.006	.004	.004	.006
PISTON ⑨	Service Replacement Sizes		.003 — .010 — .020 — .030									
	Thrust Face O.D.⑨	New	—	—	2.9329/2.9336	—	3.3700/3.3693	3.4945/3.4938	3.7465/3.7455	3.1210/3.1203	3.1215/3.1208	—
		Maximum Wear Limit	—	—	2.931	—	3.367	3.492	3.744	3.118	3.119	—
	Thrust Face To Bore Clearance (New)①⑨		—	—	.0034/.0051	—	.0045/.0062	.0050/.0067	.0030/.0050	.0035/.0052	.0030/.0047	—
	Ring End Gap	New Bore⑩	—	—	.010/.023	—	.010/.020	.010/.020	.010/.020	.010/.020	.010/.023	—
		Used Bore⑩ (Max.)	—	—	.032	—	.030	.030	.030	.032	.032	—
	Max. Ring Side Clearance		—	—	.006	—	.006	.006	.006	.006	.006	—
PISTON PIN	Outside Diameter		.5623/.5625	.6247/.6249	.6247/.6249	.8591/.8593	.8752/.8754	.8752/.8754	.8752/.8754	.6247/.6249	.7499/.7501	.8752/.8754
VALVES	Guide Reamer Size		.250	.3125	.3125	.3125	.3125	.3125	.3125	.3125	.3125	.3125
	Tappet Clearance (Cold)	Intake	.005/.009	.006/.008	.006/.008	.008/.010	.008/.010	.008/.010	.008/.010⑧	.003/.006	.003/.006	.008/.010
		Exhaust	.011/.015	.017/.019	.017/.019	.017/.019	.017/.019	.017/.019	.017/.019	.011/.014	.011/.014	.017/.020
	Minimum Lift (Zero Lash)	Intake	.2035	.2718	.2718	.318	.318	.318	.318	.274	.274	.318
		Exhaust	.1768	.2482	.2482	.318	.318	.318	.318	.274	.274	.318
	Minimum Valve Stem O.D.	Intake	.2478	.3103	.3103	.3103	.3103	.3103	.3103	.3103	.3103	.3103
		Exhaust	.2458	.3088	.3088	.3074	.3074	.3074	.3074	.3088	.3088	.3074
	Nominal Angle Valve Seat		45°	45°	45°	45°	45°	45°	45°	45°	45°	45°
	Guide I.D. Maximum Wear Limit①	Intake	.005	.005	.005	.006	.006	.006	.006	.005	.005	.006
		Exhaust	.007	.007	.007	.008	.008	.008	.008	.007	.007	.008

⑦ 

⑨ 

① Maximum limits combination of I.D. and O.D. measurements
② Ball bearing 1.3779/1.3784, Maximum Wear 1.3779
③ Ball bearing 1.7716/1.7721, Maximum Wear 1.7716
④ Pre Series II 1.3733/1.3738, Maximum Wear 1.3728
⑤ Ball bearing .002/.023
⑥ Champion spark plugs or equivalent
⑦ Measure just below oil ring groove and at right angles to piston pin
⑧ 1800 RPM generator sets .005/.007
⑨ Measure ½" above the bottom of the piston skirt.
⑩ Top and center compression rings.

Litho in U.S.A. Issued 9/86 Revised 9/88

TP-2187-C

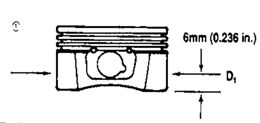
KOHLER engines

COMMAND

SPECIFICATIONS & TOLERANCES

	Description	C5 3.23 kW (5 Hp)	CV11 8.2 kW (11 Hp)	CV12.5 9.33 kW (12.5 Hp)
General Specifications	Bore Stroke	67 mm (2.64 in) 51 mm (2.01 in)	87 mm (3.43 in) 67 mm (2.64 in)	87 mm (3.43 in) 67 mm (2.64 in)
	Displacement	180 cm^3 (10.98 in^3)	398 cm^3 (24.3 in^3)	398 cm^3 (24.3 in^3)
Balance Shaft Bearing	End Play (free)	——	0.0575/0.3625 mm (0.0023/0.0143 in)	
	Bore I.D. (In Crankcase And Oil Pan, Max. Wear Limit)	——	20.038 mm (0.7889 in)	
	Balance Shaft Bearing Surface O.D. Maximum Wear Limit)	——	19.959 mm (0.7858 in)	
Camshaft	End Play (With Shims)	0.15/0.55 mm (0.0059/0.0217 in)	0.076/0.127 mm (0.003/0.005 in)	
	Bore I.D. Max. Wear Limit — In Crankcase	16.030 mm (0.6311 in)	20.038 mm (0.7889 in)	
	Bore I.D. Max. Wear Limit — In Closure Plate	25.430 mm (1.001 in)	——	
	Bore I.D. Max. Wear Limit — In Oil Pan	——	20.038 mm (0.7889 in)	
	Camshaft Bearing Surface O.D.—Max. Wear Limit — Crankcase End	15.954 mm (0.6281 in)	19.959 mm (0.7858 in)	
	Camshaft Bearing Surface O.D.—Max. Wear Limit — Closure Plate End	25.350 mm (0.9980 in)	——	
	Camshaft Bearing Surface O.D.—Max. Wear Limit — Oil Pan End	——	19.959 mm (0.7858 in)	
Connecting Rod	Connecting Rod to Crankpin Running Clearance—New	0.030/0.056 mm (0.0012/0.0022 in)	0.030/0.056 mm (0.0012/0.0022 in.)	
	Connecting Rod to Crankpin Running Clearance—Max. Wear Limit	0.0635 mm (0.0025 in)	0.0687 mm (0.0027 in)	
Crankshaft	End Play (free)	0.000/0.056 mm (0.000/0.0022 in)	0.0575/0.4925 mm (0.0023/0.0194 in)	
	Crankshaft Sleeve Bearing I.D.—Max. Wear Limit	——	45.016 mm (1.7723 in)	
	Crankshaft To Sleeve Bearing Running Clearance—New	——	0.03/0.09 mm (0.0012/0.0035 in)	
	Crankshaft To Sleeve Bearing Running Clearance—Max. Wear Limit	——	0.115 mm (0.0045 in)	
	Crankshaft Bore (In Oil Pan) To Crankshaft Running Clearance—New	——	0.03/0.09 mm (0.0012/0.0035 in)	
	Crankshaft Bore (In Oil Pan) To Crankshaft Running Clearance—Max. Wear Limit	——	0.115 mm (0.0045 in)	
	Flywheel End Main Bearing — O.D.—New	——	44.913/44.935 mm (1.7682/1.7691 in)	
	Flywheel End Main Bearing — O.D. Max. Wear Limit	——	44.950 (1.7695 in)	
	Flywheel End Main Bearing — Max. Taper	——	0.022 mm (0.0009 in)	
	Flywheel End Main Bearing — Max. Out Of Round	——	0.025 mm (0.0010)	
	Oil Pan End Main Bearing — O.D.—New	——	41.915/41.935 mm (1.6502/1.6510 in)	
	Oil Pan End Main Bearing — O.D.—Max. Wear Limit	——	41.950 mm (1.6515 in)	
	Oil Pan End Main Bearing — Max. Taper	——	0.020 mm (0.0008 in)	
	Oil Pan End Main Bearing — Max. Out Of Round	——	0.025 mm (0.0010 in)	
	Connecting Rod Journal — O.D.—New	30.947/30.960 mm (1.2184/1.2189 in)	38.958/38.970 mm (1.5338/1.5343 in)	
	Connecting Rod Journal — O.D.—Max. Wear Limit	30.934 mm (1.2179 in)	38.980 mm (1.5350 in)	
	Connecting Rod Journal — Max. Taper	0.025 mm (0.0010 in)	0.012 mm (0.0005 in)	
	Connecting Rod Journal — Max. Out Of Round	0.013 mm (0.0005 in)	0.025 mm (0.0010 in)	
Cylinder Bore	Cylinder Bore I.D. — New	67.00/67.03 mm (2.6378/2.6390 in)	87.000/87.025 mm (3.4252/3.4262 in)	
	Cylinder Bore I.D. — Max. Wear Limit	67.049 mm (2.6397 in)	87.063 mm (3.4277 in)	
	Cylinder Bore I.D. — Max. Out Of Round	0.150 mm (0.0059 in)	0.12 mm (0.0047 in)	
	Cylinder Bore I.D. — Max. Taper	0.100 mm (0.0039 in)	0.05 mm (0.0020 in)	
Cylinder Head	Max. Out of Flatness	0.076 mm (0.003 in)	0.076 mm (0.003 in)	
Governor	Governor Cross Shaft O.D.—Max. Wear Limit	6.296 mm (0.2479 in)	5.962 mm (0.2347 in)	
	Governor Gear Shaft O.D.—Max. Wear Limit	9.960 mm (0.3921 in)	5.977 mm (0.2353 in)	
	Governor Cross Shaft Bore (In Crankcase) I.D.—Max. Wear Limit	6.425 mm (0.2530 in)	6.063 mm (0.2387 in)	
Ignition	Spark Plug Type (Champion Or Equiv.)	RC12YC	RC12YC	
	Spark Plug Gap	0.76 mm (0.030 in)	0.76 mm (0.030 in)	
	Ignition Module Air Gap	0.203/0.305 mm (0.008/0.012 in)	0.203/0.305 mm (0.008/0.012 in)	
Pistons, Piston Rings, And Piston Pin	Top Compression Ring To Groove Side Clearance	0.040/0.085 mm (0.0016/0.0033 in)	0.040/0.105 mm (0.0016/0.0041 in)	
	Middle Compression Ring To Groove Side Clearance	0.040/0.072 mm (0.0016/0.0028 in)	0.040/0.072 mm (0.0016/0.0028 in)	
	Oil Control Ring To Groove Side Clearance	0.140/0.275 mm (0.0055/0.0108 in)	0.551/0.675 mm (0.0217/0.0266 in)	
	Piston Ring End Gap — New Bore	0.25/0.45 mm (0.010/0.018 in)	0.3/0.5 mm (0.012/0.020 in)	
	Piston Ring End Gap — Used Bore (Max.)	NA	0.730 mm (0.0290 in)	
	Piston Thrust Face ⓘ ("D_1") To Cylinder Bore Running Clearance — New	0.016/0.059 mm (0.0006/0.0023 in)	0.041/0.044 mm (0.0016/0.0017 in)	
	Piston Thrust Face ⓘ ("D_1") To Cylinder Bore Running Clearance — Max. Wear Limit	NA	0.076 mm (0.0030 in)	
Valves And Valve Lifters	Intake Valve To Tappet Cold Clearance	0.000/0.0508 mm (0.0000/0.0020 in)	——	
	Exhaust Valve To Tappet Cold Clearance	0.000/0.0508 mm (0.0000/0.0020 in)	——	
	Intake Valve Guide — I.D.—Std.	4.990/5.010 mm (0.1965/0.1972 in)	7.038/7.058 mm (0.2771/0.2779 in)	
	Intake Valve Guide — I.D.—Max. Wear Limit	5.085 mm (0.2002 in)	7.134 mm (0.2809 in)	
	Exhaust Valve Guide — I.D.—Std.	4.990/5.010 mm (0.1965/0.1972 in)	7.038/7.058 mm (0.2771/0.2779 in)	
	Exhaust Valve Guide — I.D.—Max. Wear Limit	5.080 mm (0.2000 in)	7.159 mm (0.2819 in)	
	Intake Valve Minimum Lift	5.4 mm (0.213 in)	8.96 mm (0.353 in)	
	Exhaust Valve Minimum Lift	5.4 mm (0.213 in)	9.14 mm (0.360 in)	
	Rocker Arm I.D.—Max. Wear Limit	——	16.004 mm (0.630 in)	
	Rocker Shaft O.D.—Max. Wear Limit	——	15.727 mm (0.619 in)	
	Nominal Valve Seat Angle	45°	45°	

NA—Specifications/Tolerances will be issued when available.
——Specification/Tolerance does not apply.



Measure 6mm above the bottom of piston skirt at right angles to piston pin.

ENGINE DIVISION KOHLER CO. KOHLER WI 53044

ISSUED 10/88
REVISED 8/89
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TP-2365-A

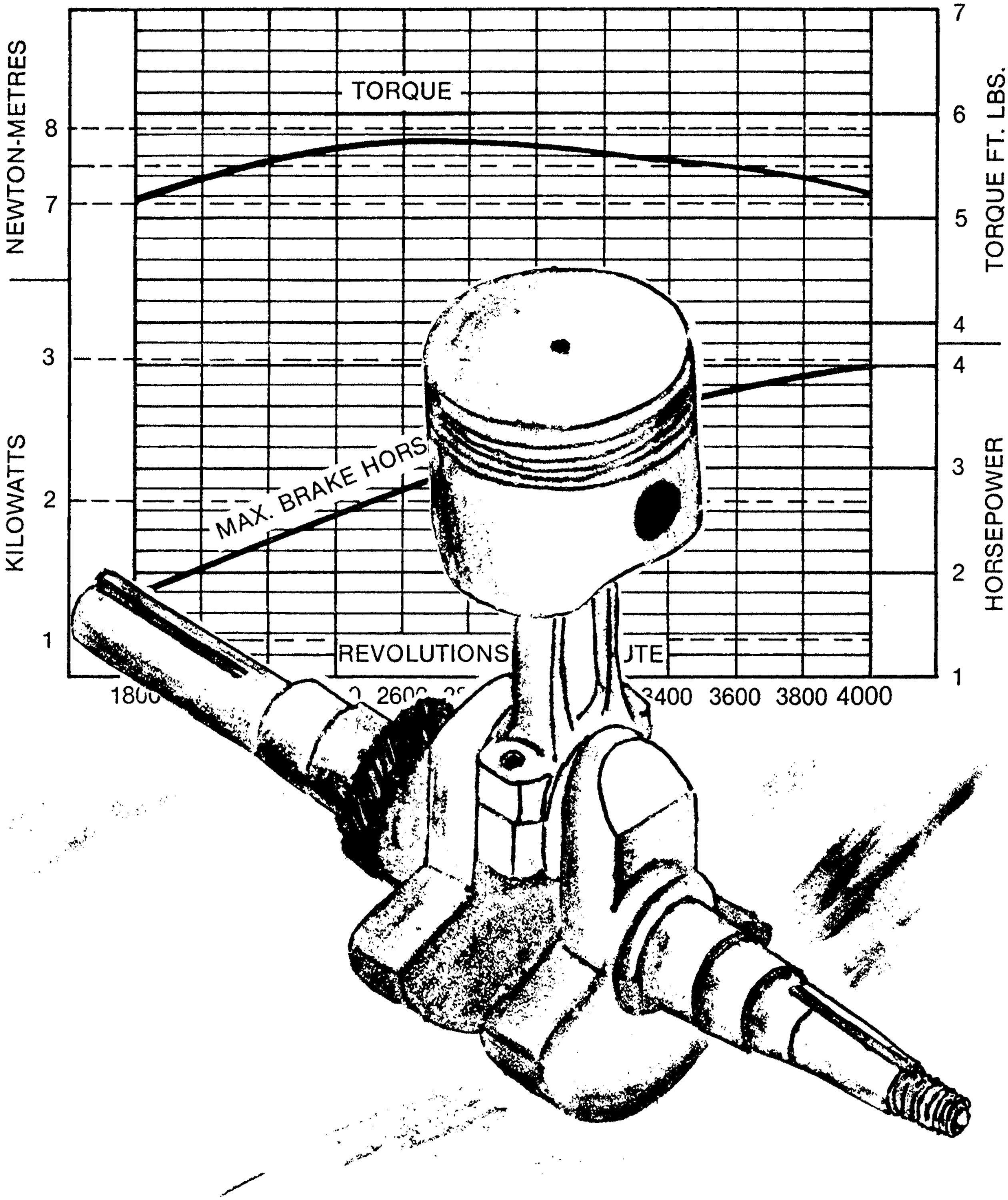
KOHLER engines

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

FORM NO.:	TP-2159-B
ISSUED:	11/83
REVISED:	9/89
MAILED:	

LITHO IN U.S.A.

PRINCIPLES OF ENGINE OPERATION



TP-2209

ENERGY SOURCES

Our living standards have improved in direct proportion to our ability to harness various forms of energy to do our work for us.

Our first accomplishment was to domesticate and train animals to carry materials and eventually to pull simple machines. Later we learned to put flowing water to work for us by means of water wheels. (Today a portion of the electricity we use in homes and factories is developed from turbines and generators—an application of that age-old water wheel principle.)

Next came the use of the so-called fossil fuels, coal and oil. Converting the latent energy of coal and oil into useful mechanical work is accomplished in a variety of ways, as discussed below.

The sun is the original source of energy in fossil fuels. Coal and oil come from former living organisms and without the sun and its energy that life would not have been possible. The sun is still pouring down a tremendous amount of energy but only a very small fraction of it is being put to work. Scientists are finding more ways of economically harnessing the energy from the sun, but much still remains to be done.

Of all the sources of energy indicated above, we obtain by far the greatest amount of work from coal and oil. The process of releasing energy from coal has reached its highest development in coal powered steam generating plants for providing electricity.

Steam engines operated from coal-fired boilers have also been used in providing useful work. However, they have many limitations and their use is decreasing. The reciprocating steam engine and steam turbines are classed as heat engines of the *external* combustion type. In other words, combustion of the fuel and release of the heat energy is accomplished at some external point of the engine.

In contrast to this, the release of energy from oil has reached a high state of development in the *internal* combustion engine. For example, the gas turbine type of engine such as used in jet aircraft is one form of internal combustion engine. This text will concentrate on the reciprocating, or piston type internal combustion engine.

HISTORICAL HIGHLIGHTS*

To get a good over-all understanding of any subject, it helps to have some knowledge of its history and development. Briefly, here are some of the highlights of internal combustion engine history.

In 1824, Carnot, a Frenchman, described a theoretical heat engine process. This was an ideal process and is still recognized as the aim in the development of any engine. However, it is interesting to note that to this date engineers have been unable to develop the maximum conversion of heat energy into work as was described in Carnot's theory.

In 1838, Barnett, an Englishman, described a two-stroke cycle engine. His description also was theoretical and many difficulties were encountered attempting to develop a working model.

During the Civil War period, Beau de Rechas, a Frenchman, set forth the principles of the four-stroke cycle. However, it was not until 1873 that a German by the name of Otto built the first *successful* four-stroke cycle engine. The gasoline engine to this day is often called an "Otto cycle" engine.

In 1892, another German, Rudolph Diesel, proposed an engine in which the air and fuel mixture would be ignited by the heat developed during rapid compression.

The development of engines in the 19th century was influenced by the need for pumping water from coal mines. The use of coal was accelerating and it became necessary to go deeper into the ground for more coal, rendering hand powered pumps impractical as the volume and lift of water to be handled increased. The first engines developed for the mine applications were huge machines of small power output.

*For a comprehensive historical outline of the history of engine power, ask your Kohler Distributor for a copy of "Introduction to Engine Power" (TP-2196).

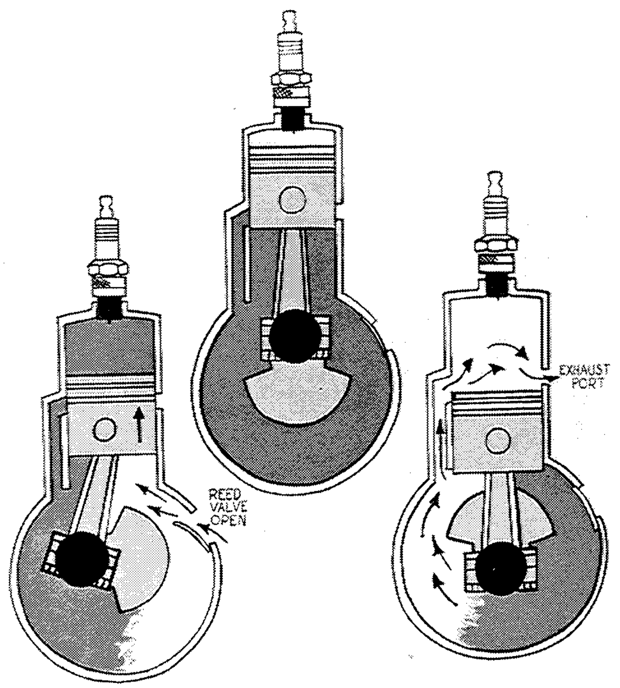
Three functions involving air-fuel mixture are necessary for internal combustion engines to operate: (1) Compression; (2) Ignition; and (3) Combustion, and they are engineered to perform those functions either through two-stroke cycle or four-stroke cycle designs.

A stroke is defined as movement of the piston from one end of its travel to the other. It may be either toward the crankshaft or away from it.

TWO-STROKE CYCLE

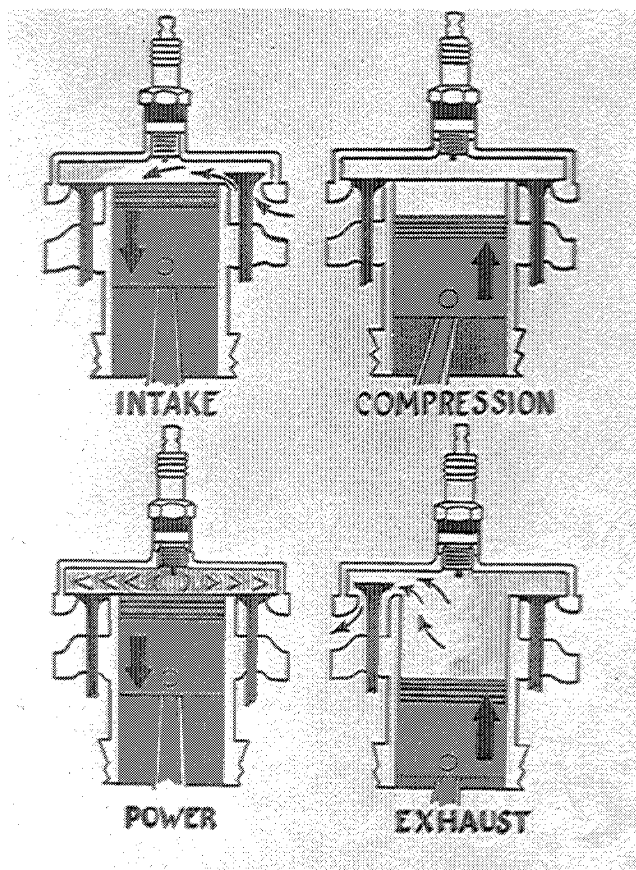
In the two-stroke cycle engine (or two-cycle engine, as shortened in every day usage), one operating cycle is completed for every two strokes of the piston or one revolution of the crankshaft. Air is usually introduced through holes or ports in the cylinder wall.

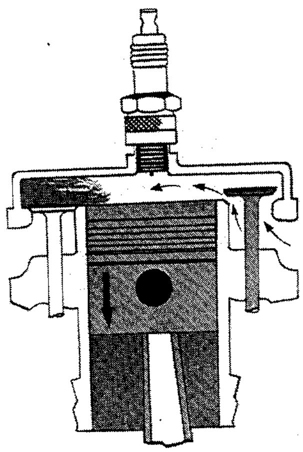
As the piston moves up, these ports are closed and the charge is compressed. The fuel and air mixture is ignited when the piston is near the top dead center, and the rapid burning and expansion of the gases forces the piston downward again. Part way down in its travel, other ports are opened allowing the burned gases to exhaust and clean the cylinder in preparation for the next incoming charge. Two-cycle operation is used today in both gasoline and Diesel engines.



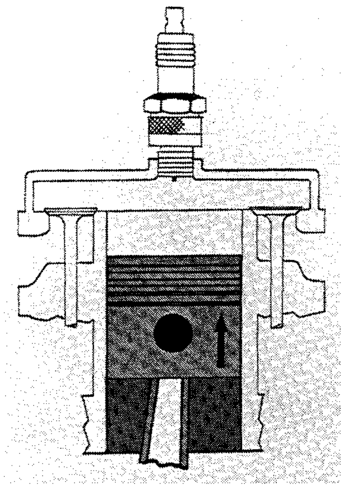
FOUR-STROKE CYCLE

In the four-stroke cycle engine (or, four-cycle), one operating cycle is completed for every four strokes of the piston, or two revolutions of the crankshaft.

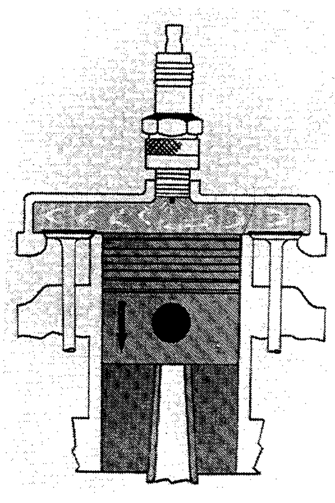




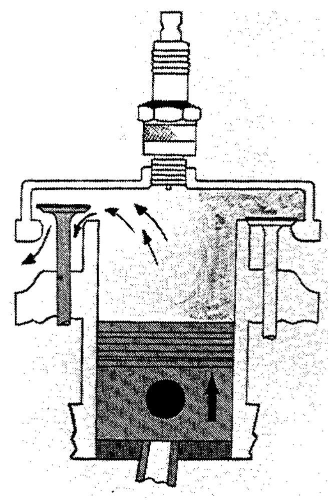
Intake Stroke—At the beginning of this stroke, the piston is at the position closest to the cylinder head, thereby filling the cylinder space and reducing the open volume of the cylinder and combustion chamber to a minimum. As the piston moves toward the crankshaft and with the intake valve open, air is drawn into the cylinder.



Compression Stroke—With air in the cylinder and the piston at the point closest to the crankshaft, the intake valve closes. As the piston travels toward the top of the cylinder, the air in the cylinder is compressed. In the gasoline engine, the fuel is already mixed with the air as it is drawn into the cylinder. In the Diesel engine, fuel is injected into the cylinder toward the end of the compression stroke. In both gasoline and Diesel engines, just before it reaches top dead center, or the point where it is farthest from the crankshaft, the charge is ignited.



Power Stroke—As the fuel burns in the cylinder, heat is released causing a rapid pressure buildup as the gases expand. This pressure causes the piston to move downward, and through the mechanism of the connecting rod and crankshaft delivers useful energy to the rotating crankshaft.



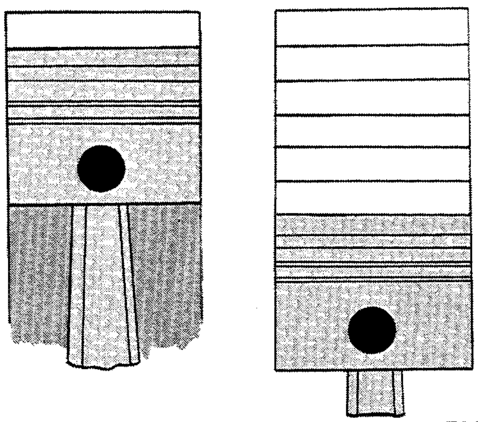
Exhaust Stroke—At the end of the power stroke, the exhaust valve opens, and as the piston moves upward it forces the exhaust out of the cylinder. The exhaust valve closes at the end of this stroke and the engine is ready to repeat the cycle.

1—ENGINE COMPRESSION

Displacement of an engine is indicated in cubic inches and is a measure of the size, or potential power of that engine. By definition, it is the volume which the piston displaces. In other words, the displacement of a single cylinder engine can be calculated as follows: Piston area multiplied by the length of stroke, or

$$\frac{\pi}{4} \times (\text{Cylinder bore})^2 \times \text{Stroke.}$$

For a multi-cylinder engine, simply multiply this quantity by the number of cylinders in the engine.



6 TO 1 RATIO GASOLINE ENGINE

Compression ratio is another engine measurement. In every engine there is a small volume of air around the heads of the valves and in the contours of the combustion chamber, even when the piston is at top dead center. This is called the clearance volume. This volume, plus the piston displacement is the total volume. Compression Ratio (C.R.) is defined as the Total Volume divided by the Clearance Volume—or Displacement plus Clearance Volume divided by Clearance Volume. As a formula it may be expressed:

$$C.R. = \frac{V_{Total}}{V_{Clearance}} \quad \text{or} \quad \frac{V_{Displ.} + V_{Clear.}}{V_{Clearance}}$$

The amount of power an engine develops is directly related to the degree of compression achieved in the cylinder. The efficiency with which the fuel is burned is also higher with a high degree of compression. This is the reason for the trend in automotive engines toward higher compression ratios.

Progress toward higher compression ratios is limited by the burning characteristics of the fuel. In overhead valve engines, where the valves are normally over the engine, there are no limitations in design for achieving a high compression ratio because it is easy to design such an engine with a small clearance volume. With "L" head engines it is not easy to keep the clearance volume small and therefore compression ratios are limited in the range of 6 to 6.5.

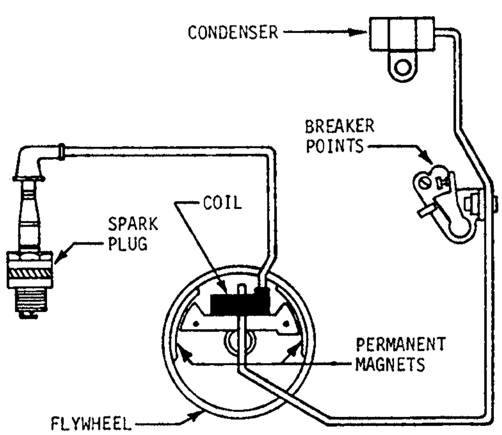
The engine components that hold the compression and power stroke pressures in the cylinder are the valves and seats, the cylinder head gasket and the piston rings. To get proper power from a given engine and to get proper starting characteristics, there can be no leakage through any of these parts.

In Diesel engines the pressures in the cylinder during compression and combustion range from 700 to 1200 psi as compared with 300 to 500 psi in gasoline engines. Compression ratios in Diesel engines range from 15:1 to 20:1 as compared with 5.5:1 to 10.5:1 for gasoline engines.

As air is compressed in the Diesel engine cylinder, its temperature increases, and as this occurs very rapidly, there is insufficient time for the heat to escape to the surrounding cylinder walls. With the high compression ratio and rapid compression of the air, temperatures are reached which ignite the Diesel fuel when it is injected into the cylinder. This is known as compression ignition and is the characteristic operating principle of Diesel engines.

2—IGNITION

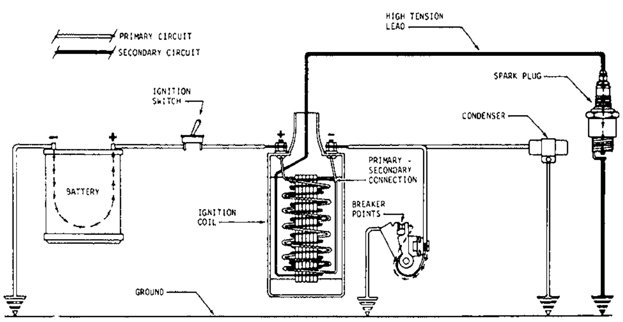
In gasoline engines the fuel and air mixture is ignited by means of an electric spark. The spark bridges, or "jumps", the gap from one spark plug electrode to the other in the combustion chamber. The electricity for that spark must be of sufficiently high voltage in order to jump the gap and ignite the fuel, but is of relatively small current flow.



TYPICAL FLYWHEEL MAGNETO IGNITION SYSTEM

The high voltage is produced in a coil. The coil has two windings. Current is flowed at low voltage through the primary winding of the coil which is relatively heavy wire and few turns. The charge of current in this winding causes a high voltage, low amperage current in the secondary winding. This is true of both magneto and battery ignition systems. The current for the primary winding of a battery ignition system comes from the battery.

In a magneto system this primary current is generated within the coil through the process of electromagnetic induction (refer to Engine Ignition Systems, TP-2210). Interruption of the primary current by means of breaker points on both battery and magneto systems causes a rapid change in the coil and thereby produces the high voltage necessary at the spark plug. This voltage may run as high as 20,000 volts with approximately 7,000 being required for initial starting.



PRIMARY (LOW VOLTAGE) AND SECONDARY (HIGH VOLTAGE) CIRCUITS

Timing of the spark is essential to obtain maximum power from the engine. The point at which the spark should occur will vary with the speed and the design of the engine. Under running conditions, the spark should occur before the piston reaches top dead center so that the burning of the fuel has started before the piston begins its downward stroke. Maximum pressure is necessary to get the maximum work from the rapidly expanding gases.

ELECTRONIC IGNITION

Most newer engines are equipped with the electronic (solid state) type of ignition system. In this system, as the flywheel rotates and the magnet assembly moves past the ignition module, a low voltage is induced in the primary windings of the module. When the primary voltage is precisely at its peak, the module induces a high voltage in its secondary windings. This high voltage creates a spark at the tip of the spark plug, igniting the fuel-air mixture in the combustion chamber. The timing of the spark is automatically controlled by the module. Therefore, no ignition timing adjustments are necessary, or possible with this system.

3—COMBUSTION

Contrary to most opinions, combustion is not an explosion, or a simultaneous burning of all parts of the fuel and air mixture.

Desired engine combustion is a progressive burning of the fuel and air mixture. The flame starts at the spark plug and travels in all directions from that point. It can be influenced by extreme turbulence of the fuel and air mixture. Researchers have actually photographed this flame front at various stages as it proceeds across the combustion chamber.

As the flame travels, heat is generated and gaseous products of combustion are released. A rapid buildup of pressure results. This pressure is also built up on the forward side of the flame in the fuel and air mixture which the flame has not yet reached. The pressure and temperature of this forward part of the mixture may reach the point where it is ignited by itself, similar to Diesel ignition.

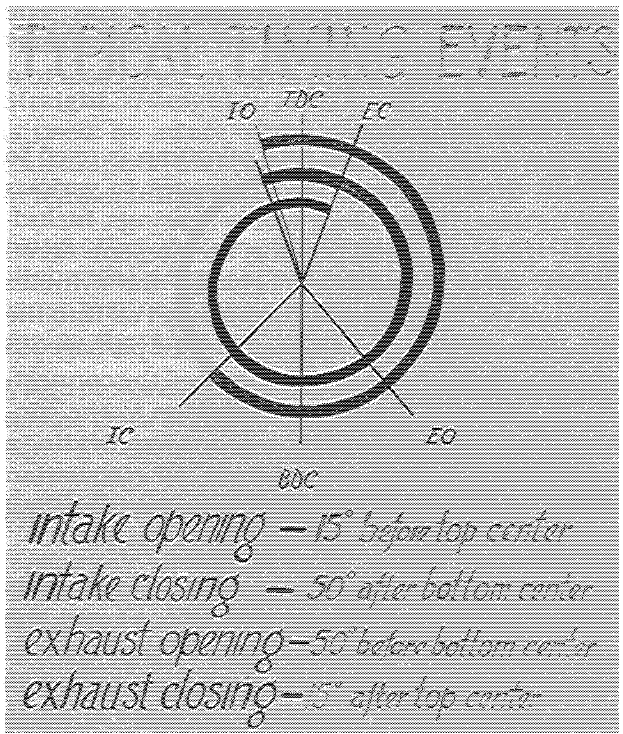
A very rapid buildup of temperature and pressure is produced and combustion becomes uncontrolled. Ignition of the charge in front of the flame front is known as auto-ignition or detonation. Another form of uncontrolled combustion is caused by some spot in the cylinder remaining hot enough after the exhaust stroke to ignite the incoming mixture before the normal spark ignition. This causes an abnormal buildup of pressure, rough sounding operation, and loss of power. It is known as pre-ignition. All such forms of uncontrolled combustion result in excessive pressures on rings, pistons, cylinder heads, and bearings and loss of power output. Extended operation under such conditions will lead to mechanical failure of some part of the engine.

The air and fuel mixture in a gasoline engine must be within certain limits in order to ignite and burn. The extreme limits of the ratio of air to fuel weights are approximately 7:1 for a rich mixture and 20:1 for a lean mixture. For most engines this mixture usually falls in the range from 10.5:1 to 14:1, with maximum power usually obtained around 13:1 air-fueled ratio.

In a Diesel engine, combustion starts shortly after the beginning of fuel injection. The fuel is sprayed into the combustion chamber at a carefully calibrated rate. The amount of power the engine will develop is determined by the length of time the fuel is injected. The pumps are so constructed that this time is varied according to the setting of the governor. In comparison, the governor on a gasoline engine varies the position of the carburetor throttle, while the governor on a Diesel engine varies the length of time that fuel is sprayed into the cylinder.

VALVE TIMING & LIFT

Referring again to the four basic strokes in a four-stroke cycle engine, the opening of the intake valve must begin before the start of the intake stroke. During the first part of the valve opening, movement is small in comparison with crank angle travel. In order to have the valve open a suitable amount by the time the piston starts drawing air in the cylinder, the start of the opening of the intake valve must begin before the piston reaches top dead center. Then it must open as fast as mechanically possible and far enough to provide the minimum resistance to flow of air through the valve port.



When the piston approaches bottom dead center, air is being drawn in at a rapid rate. Because the air has inertia the intake valve may be kept open somewhat beyond bottom dead center so the momentum of the air into the intake system will tend to pack more air into the cylinder. The ideal place to close the intake valve would be at the point where air movement through the intake valve starts to reverse itself. In most high speed engines in use today, this point will range from 35° to 65° of crank travel beyond bottom dead center.

Intake valve closing, therefore, is always after bottom dead center, and is specified in those terms. Both valves are closed during the compression stroke and the early part of the power stroke. During the power stroke, some of the energy from the expanding gases is sacrificed to make sure that the exhaust gases are completely cleared from the cylinder in preparation for the next intake stroke. It is common practice to open the exhaust valve before bottom center for intake valve opening.

Cams are designed to provide: (1) a clearance of a few thousandths of an inch during a part of the cycle when the valves must be closed, (2) a ramp for engaging the valve and starting its lift, (3) a portion to accelerate the valve to maximum opening velocity, (4) a section to decelerate it to a stop at the cam nose, and (5) the other half of the cam lobe which closes the valve again through the same sequence but in reverse.

The intake manifold, valve ports, and throat area of the combustion chamber must be of such size and shape that air may flow through with minimum restriction. Accumulations of carbon or lead deposits in any of these area will immediately decrease the maximum power.

FLYWHEEL

An engine produces its power during the power stroke only. Therefore, there must be sufficient momentum built into the engine to carry it through the other three strokes without injurious loss of speed. This function is performed by the flywheel.

Flywheels ordinarily are designed somewhat on the light side to reduce engine weight, and also depend on the equipment being driven by the engine for part of the flywheel action. Even at best, there is always some slowing down of the engine between power strokes. This slowing down and subsequent speeding up during the power stroke is termed *cyclic irregularity.* This becomes an important consideration on those applications where the functions of couplings, drive pulleys or clutches is effected. Such components must be adequate to take this speed variation.

ENGINE VIBRATION & BALANCE

In a single cylinder engine the reciprocating action of the piston and connecting rod causes a shaking action which must be controlled as much as possible by balancing. By adding a counter-weight on the crankshft opposite the crank throw, the reciprocating unbalance can be counteracted. If a 100% counteraction is provided in the direction of the unbalance force, then the counterweight sets up an equal unbalance in a plane perpendicular to the axis of the cylinder. Kohler single cylinder engines are dynamically balanced. The balance of multi-cylinder engines is more complex, but the same basic principles apply.

COOLING

Cooling of valves is a critical part of engine performance. The intake valve ordinarily does not achieve excessively high temperatures. It is cooled by the incoming air and fuel mixture.

The exhaust valve receives the full blast of the exhaust gases. Ordinarily at wide open throttle it will be red hot. (You can see it through the exhaust port). To withstand such temperatures, the valve head must be of stainless steel or it will corrode very rapidly. For extreme conditions, the face of the valve must also be coated with Stellite® to provide sufficient hardness and corrosion resistance. Valve rotators aid in providing good valve life under heavy load conditions.

The exhaust valve transfers its heat through the stem and into the guide, which in turn conducts it to the outside of the cylinder block. Some valve heat is also transferred through the seating face to the valve seat insert and from there to the surrounding portion of the block.

Providing adequate cooling air (or cooling water, depending on the type of engine) to that portion of a cylinder block is of prime importance. The cylinder head contains most of the combustion chamber and becomes hot during the power stroke. It must be cooled so that the head itself retains its physical strength and shape and to prevent the hot spots from developing in the combustion chamber, causing pre-ignition. The piston is cooled, to some extent, by oil splashing against the underside of it. The piston rings transmit heat from the piston to the cylinder walls. The heat picked up by the cylinder walls, plus that resulting from direct exposure to the combustion flame, must be disposed of by air forced through cooling fins around the cylinder of an air-cooled engine (or by a water jacket on the water-cooled engines).

If the cylinder is inadequately cooled, the oil temperature tends to run high and will break down in the ring section causing ring sticking and excessive carbon and varnish buildup. Providing a blower for cooling air requirements of an engine, whether it be air cooled or radiator cooled, ordinarily takes from 5% to 10% of the available engine power.

LUBRICATION

A very thin film of oil is adequate to lubricate cylinder walls. The rings are designed to scrape excess oil from the walls and prevent passage of excessive amounts to the combustion chamber. Gasoline and Diesel engines are lubricated to some extent on the upper portion of the cylinder by the fuel itself. When operating on gaseous fuels, such as propane and natural gas, some engines run so dry that a top oiler must be added for providing sufficient lubrication for the upper end of the piston travel.

The connecting rod bearings are critical parts of the engine. High and varying pressures and high rotating speeds make the lubrication job at this point important.

In splash lubricted engines, the oil must find its way into the bearing surface through drilled holes or grooves after being picked up as droplets during the rotation of the crank and connecting rod. The simplicity of a splash lubrication system is desirable on smaller engines in order to keep costs to a minimum.

On larger engines, a gear type oil pump is used to force oil through the drilled passages to various spots in the cylinder block where bearings, including the connecting rod bearing, are present. An oil transfer sleeve is provided between the cylinder block and the crankshaft in order to get oil into the shaft. From there it goes through drilled passages to the crank pin journals where they feed the connecting rod bearings. Pressure lubrication to the connecting rod bearings is advantageous in providing a more positive supply and definite oil circulation through the bearings. A certain amount of cooling of the bearings is accomplished with the oil.

The lubrication of sleeve type main bearings is provided by oil pumps and drilled passages, the same as for the rod bearings. An anti-friction bearing needs very little lubrication. In fact, it is undesirable to allow excessive amounts of oil to pass through the bearings.

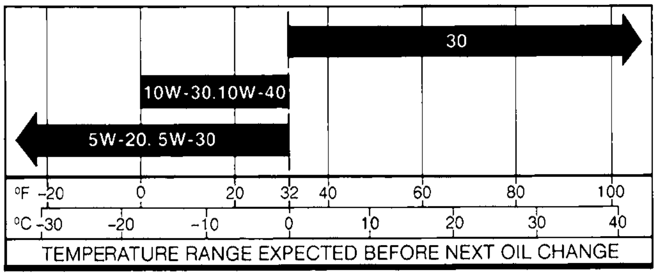
Camshafts, timing gears, governor, magneto, and oil pump drive gears are very lightly loaded and receive adequate lubrication just from oil thrown off from other parts in their vicinity. The camshaft bushings on larger engines receive pressure lubrication, but it is not at all critical. Lubrication around the flyweights of a governor must be moderate and excessive amounts of oil will adversely affect the action of the flyweights. Reduction gears are highly stressed and must be lubricated very carefully.

OIL RECOMMENDATIONS

The importance of checking, changing, and using the proper crankcase oil cannot be overemphasized. Failure to use the correct oil can affect engine life and reliability.

Oil Type

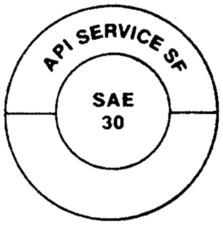
Use high quality detergent oil of API (American Petroleum Institute) service class SF. Viscosity should be based on the air temperature at the time of operation as shown below:



Straight 30 weight oil is preferred. If multi-viscosity is used, be aware of the resulting increase in oil consumption and combustion deposits when used in temperatures above 32° F (0° C).

Using other than service class SF oil, or extending oil change intervals longer than recommended could cause engine damage which is not covered by the engine warranty.

A logo or symbol on oil containers identifies the API service class and SAE viscosity grade.



The top portion of the symbol shows the service class, which may be SF, SF/CC, CD, or others. The center portion shows the viscosity grade such as SAE 30 in the example. If the bottom portion shows "Energy Conserving," it means the oil is intended to improve fuel economy in passenger car engines.

There are a number of special additives on the market. Although some of these materials have merit for certain conditions on some engines, we believe that with adequate maintenance and proper engine use, special additives are unnecessary.

FUELS

Gasoline—Petroleum is a mixture of a large number of different hydrocarbons—materials composed of hydrogen and carbon. These two elements may be combined in a wide variety of ways with each combination being quite stable and having its own individual boiling point and ignition point. This charactertistic varies quite widely, depending on how the gasoline was refined. The characteristic of a varying boiling and ignition point is the principle reason for gasoline being a superior engine fuel.

The basic chemistry of gasoline allows it to burn in a controlled sequence according to the temperature and pressure required for the various hydrocarbon materials.

Octane is one of the hydrocarbon compounds in gasoline. It has superior anti-knock characteristics and at one time was considered the ideal or nearly perfect engine fuel. It was therefore used as a basis for comparing the anti-knock performance of various gasolines. The octane rating has developed from this concept. Two different octane ratings are in current usage: the pump sticker rating and the research rating method, which is primarily used in Canada, and is always a higher rating.

For best results, use only clean, fresh, regular grade unleaded gasoline with a pump sticker octane rating of 87 or higher in the U.S.A. In countries using the Research rating method, it should be 90 octane minimum.

Unleaded is recommended since it leaves less combustion chamber deposits. Regular grade leaded gasoline may also be used; however, be aware that the combustion chamber and cylinder head will require more frequent service.

When gasoline is stored for any extended period of time, certain portions of it tend to oxidize and thereby form a heavy gummy substance. This gum can plug up the tiny holes in carburetors and thereby cause unsatisfactory engine performance. The best way to avoid this condition is to avoid lengthy storage of the gasoline.

Alcohol, on the other hand, is a single chemical compound with a single boiling and ignition point for a given pressure. When alcohol is used as a fuel it has a tendency to burn too rapidly and uncontrollably.

Gaseous fuels—Engines can be made to run on gaseous fuels such as propane, butane, natural, or manufactured gas. The energy potential of these fuels is as follows:

Propane-Butane	—	2600-3000 BTU/cu. ft.
Natural Gas	—	1000 BTU/cu. ft.
Manufactured Gas	—	400-600 BTU/cu. ft.

Natural gas, being roughly 1/3 the BTU value of propane, must be supplied in three times the volume required for propane for a given engine power output. Manufactured gas is always quite low on BTU value and is sometimes modified or enriched with natural gas. It is important to know which gas is to be used when furnishing carburetion equipment for a specific job. The low value gases require regulators, lines, etc. which will supply many times the volume of propane gas for a given power output required.

One big advantage of gaseous fuels is their freedom from tetraethyl lead. Deposits in the combustion chamber are kept to a minimum.

Diesel fuel—The Diesel fuel is simply specified as grade #1 and #2. Grade #1 is generally a lighter weight or lower viscosity.

Cetane rating is the quality of Diesel fuel and compares with octane rating in gasoline. The minimum cetane rating is usually considered 45. In low temperatures, it is quite common for Diesel fuels to become jelly-like. The point at which they cease being a liquid is known as the pour point. This fuel quality should be watched carefully in temperatures of 20° F or lower.

RATING ENGINES

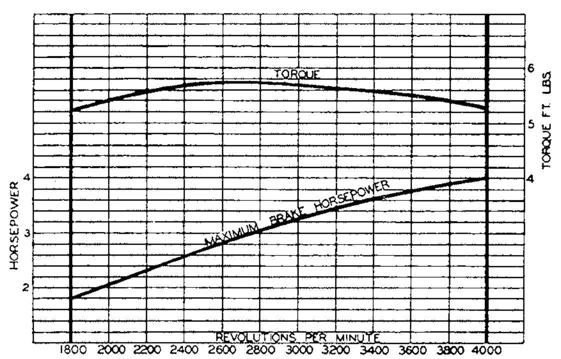
All small engine manufacturers use the Society of Automotive Engineers (SAE) test code J607 to rate their engines. The test code establishes:

- 29.92 inches (760 mm) of Mercury as standard barometric pressure (sea level), and
- 60° F (15.6° C) as standard temperature

at which engines are rated. It is general practice to rate engines at the maximum amount of power—Maximum Brake Horsepower (B.H.P.)—they produce under those laboratory conditions.

Unfortunately, engines do not usually operate under those same test conditions. Actual horsepower (kilowatt) output is affected by temperature and barometric pressure (elevation above sea level).

The performance of an engine under those laboratory conditions is generally plotted on a Brake Horsepower or Power Data Curve.



Four operating conditions have an effect on useable engine horsepower and must be considered when selecting an engine: (1) Duty Cycle; (2) Altitude; (3) Temperature; (4) How the engine will be "connected" to the load.

These conditions are not unusual—they are normal and apply to all makes and models of engines. Each condition has an industry-accepted factor which must be allowed for when calculating the available horsepower of an engine.

Engine Torque & Torque Curves

The shape of the torque curve is important on many applications. It is desirable to have a torque curve which is fairly flat or gently drooping toward the low end of the speed range. At the high end of the speed range it should be approximately 10% lower than medium range in order to provide an increase in torque as the engine is pulled down in speed on heavy load. This gives the engine a good lugging characteristic. The torque curve is modified by modifying valve timing in the initial development of the engine.

EFFECTS OF OPERATING CONDITIONS

Four operating conditions have an effect on useable engine horsepower and must be considered when rating an engine: (1) Duty Cycle; (2) Altitude; (3) Temperature; (4) "Connecting" to the load.

These conditions are not unusual—they are normal and apply to all makes and models of engines. Each condition has an industry-accepted factor which must be allowed for when calculating the available horsepower of an engine.

(Refer to page 12 for an example of how to calculate useable engine horsepower.)

1. Duty Cycle

Engines are rated at maximum allowable RPM and wide open throttle (WOT)—meaning that an 8 HP engine will deliver 8 HP under laboratory conditions. If that same engine were continuously operated in an application at that power, its life could be shortened.

To offset excessive application demands and, thereby, increase engine performance and engine life, it is recommended that the following duty cycle factors be included in determining useable horsepower:

- ***For Constant Duty***, at constant speed and load—***an 80% factor*** should be used
- ***For Intermittent Duty***, with 50 percent or less duty cycle—***an 85% factor*** should be used.

2. Effects of Altitude

Engines are rated using barometric pressure at sea level. With an increase in altitude, such as going up a mountain, there is a decrease in barometric pressure—and a proportionate decrease in engine horsepower.

- Horsepower ***decreases 3.5% for each 1000*** feet above sea level.

This reduction must be taken into account if the engine is to be used at higher elevations.

3. Effects of Temperature

Engines are rated at 60° F. Increased temperatures to the carburetor will cause a predictable loss of power.

- Horsepower ***decreases 1% for every 10°*** above 60° F.

Allow for higher carburetor inlet temperatures than 60° F due to operating conditions.

4. Transmission Efficiencies

Types of Drives—Power is taken from engines either by means of coupling directly to the crankshaft or by means of belt and pulley or chain and sprocket types of drive. If the equipment is direct coupled, the type of coupling and the alignment between the engine shaft and equipment shaft is important. If it is direct coupled with a solid coupling, alignment must be kept within a few thousandths of an inch. If a flexible type coupling is used, some additional misalignment can be allowed but if the misalignment is excessive and the coupling flexes to a considerable degree it is possible to lose much engine power right in the coupling.

When using "V" belt drives it is important that the size of the drive pulley and belt be suitable for the amount of power being transmitted. Many times it is necessary to use several "V" belts on the larger engines. When using a chain and sprocket type of drive, the tension on the chain is of importance because there may be a whipping action due to the engine speed variation from one cycle to the next (cyclic irregularity). This may be injurious to both engine and equipment. "V" belts, with their ability to stretch, act somewhat as a shock absorber and are much easier on the engines.

Sometimes customers require a clutch between the engine and their equipment, which is frequently purchased separately from clutch manufacturers.

There may also be the requirement for a reduction in rotating speed for which gear reductions are available. In working with a gear reduction it should always be kept in mind that engine torque is multiplied by the same ratio as the speed is reduced. With a chain and sprocket type drive on a gear reduction, firmness of engine mounting becomes essential. If the chain is directed out to the side of the engine, the torque tends to twist the engine and may show up as loosened mounting cap screws or loose screws between the engine block and base. Combination clutch and reduction units can also be applied to engines. These applications should always be discussed with the engine manufacturer.

There are normal losses of engine power to the equipment depending upon the method of connecting the engine to the load. Refer to the chart as a guide for efficiency values for common transmission equipment:

Transmission Equipment	Typical Efficiency
Direct Coupled	100%
V-Belts	96-98%
Roller Chain	95-97%
Spur Gears	96%
Gear Reducers	Consult Manufacturer

(Refer to page 12 for an example of how to calculate useable engine horsepower.)

Example of Calculations:

CALCULATING USEABLE HP:

Application: Fan

Load: 8 HP @ 3600 RPM (Manufacturer's specs)

Duty Cycle: Constant

Altitude: Up to 4000 ft.

Temperature: (Max) 100° F

Power Transmission: V-belts

1. **Duty Cycle** = use 80% factor (constant)
2. **Altitude** = 4000 ft. X $\frac{3.5\% \text{ Loss}}{1000 \text{ ft.}}$ = 14% loss (or 86% available)
3. **Temperature** = (100°—60°) X $\frac{1\%}{10}$ = 4% loss (or 96% available)
4. **Power Transmission** = V-belt (97% efficient)

The engine HP actually required for this application can now be determined from the following formula:

Engine Hp Required (Unknown) X Duty Cycle .80 X Altitude effect .86 X Temperature effect .96 X Transmission .97 = 8 HP Required to drive fan or,

$$\frac{\text{8 HP Required to Drive Fan}}{\text{Duty Cycle .80} \times \text{Alt. Effect .86} \times \text{Temp. Effect .96} \times \text{Trans. Effic. .97}} = \text{Minimum 12.4 HP Engine Actually Required}$$

KOHLER engines

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

KOHLER engines

SPECIFICATIONS & TOLERANCES
TORQUE VALUE & SEQUENCES

SPECS & TORQUES

Table of Contents

Standard Application Torque Recommendations

Torque values are in N·m. Values in parenthesis ( ) are English equivalents.

Metric Fastener

Tightening Torque: N•m (in. lb.) + or – 10%

Size	Property Class 4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M4	1.2 (11)	1.7 (15)	2.9 (26)	4.1 (36)	5.0 (44)	2.0 (18)
M5	2.5 (22)	3.2 (28)	5.8 (51)	8.1 (72)	9.7 (86)	4.0 (35)
M6	4.3 (38)	5.7 (50)	9.9 (88)	14.0 (124)	16.5 (146)	6.8 (60)
M8	10.5 (93)	13.6 (120)	24.4 (216)	33.9 (300)	40.7 (360)	17.0 (150)

Tightening Torque: N•m (ft. lb.) + or – 10%

Size	Property Class 4.8	5.8	8.8	10.9	12.9	Noncritical Fasteners Into Aluminum
M10	21.7 (16)	27.1 (20)	47.5 (35)	66.4 (49)	81.4 (60)	33.9 (25)
M12	36.6 (27)	47.5 (35)	82.7 (61)	116.6 (86)	139.7 (103)	61.0 (45)
M14	58.3 (43)	76.4 (55)	131.5 (97)	184.4 (136)	219.7 (162)	94.9 (70)

Oil Drain Plugs (All Models)

Size	Into Cast Iron	Into Aluminum
1/8" NPT	–	4.5 (40 in. lb.)
1/4"	17.0 (150 in. lb.)	11.3 (100 in. lb.)
3/8"	20.3 (180 in. lb.)	13.6 (120 in. lb.)
1/2"	27.1 (20 ft. lb.)	17.6 (13 ft. lb.)
3/4"	33.9 (25 ft. lb.)	21.7 (16 ft. lb.)
X-708-1[1]	27.1/33.9 (20/25 ft. lb.)	27.1/33.9 (20/25 ft. lb.)

Torque Conversions

N•m = in. lb. x 0.113
N•m = ft. lb. x 1.356
in. lb. = N•m x 8.85
ft. lb. = N•m x 0.737

English Fastener

Tightening Torque: N•m (in. lb.) + or – 20%

Size	Bolts, Screws, Nuts and Fasteners Assembled Into Cast Iron or Steel: Grade 2	Grade 5	Grade 8	Grade 2 or 5 Fasteners Into Aluminum
8-32	2.3 (20)	2.8 (25)	---------	2.3 (20)
10-24	3.6 (32)	4.5 (40)	---------	3.6 (32)
10-32	3.6 (32)	4.5 (40)	---------	---------
1/4-20	7.9 (70)	13.0 (115)	18.7 (165)	7.9 (70)
1/4-28	9.6 (85)	15.8 (140)	22.6 (200)	---------
5/16-18	17.0 (150)	28.3 (250)	39.6 (350)	17.0 (150)
5/16-24	18.7 (165)	30.5 (270)	---------	---------
3/8-16	29.4 (260)	---------	---------	---------
3/8-24	33.9 (300)	---------	---------	---------

Tightening Torque: N•m (ft. lb.) + or – 20%

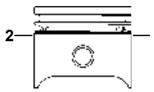
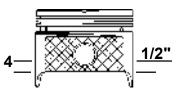
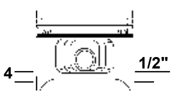
Size	Grade 2	Grade 5	Grade 8	Grade 2 or 5 Fasteners Into Aluminum
5/16-24	---------	----------	40.7 (30)	---------
3/8-16	---------	47.5 (35)	67.8 (50)	---------
3/8-24	---------	54.2 (40)	81.4 (60)	---------
7/16-14	47.5 (35)	74.6 (55)	108.5 (80)	---------
7/16-20	61.0 (45)	101.7 (75)	142.4 (105)	---------
1/2-13	67.8 (50)	108.5 (80)	155.9 (115)	---------
1/2-20	94.9 (70)	142.4 (105)	223.7 (165)	---------
9/16-12	101.7 (75)	169.5 (125)	237.3 (175)	---------
9/16-18	135.6 (100)	223.7 (165)	311.9 (230)	---------
5/8-11	149.2 (110)	244.1 (180)	352.6 (260)	---------
5/8-18	189.8 (140)	311.9 (230)	447.5 (330)	---------
3/4-10	199.3 (150)	332.2 (245)	474.6 (350)	---------
3/4-16	271.2 (200)	440.7 (325)	637.3 (470)	---------

[1]3/8-16 thread with hex. head nut and fiber gasket.

K-Series–Single Cylinder Engine Specifications & Tolerances

All dimensions in inches.

Model (Horsepower)			K91 (4)	K161 (7)	K181 (8)	K241 (10)	K301 (12)	K321 (14)	K341 (16)
General	Bore x Stroke		2.375 x 2.000	2.938 x 2.500	2.938 x 2.750	3.251 x 2.875	3.375 x 3.250	3.500 x 3.250	3.750 x 3.250
	Displacement Cu. In.		8.86	16.94	18.64	23.85	29.07	31.27	35.90
	Max. Operating RPM		4000	3600	3600	3600	3600	3600	3600
Balance Gear	Shaft O.D.	New	–	–	–	0.4998/0.5001	0.4998/0.5001	0.4998/0.5001	0.4998/0.5001
		Max. Wear Limit	–	–	–	0.4996	0.4996	0.4996	0.4996
	End Play		–	–	–	0.002/0.010	0.002/0.010	0.002/0.010	0.002/0.010
Camshaft	End Play		0.005/0.020	0.005/0.010	0.005/0.010	0.005/0.010	0.005/0.010	0.005/0.010	0.005/0.010
Connecting Rod	Running Clearance	Rod to Crankpin (New)	0.001/0.0025	0.001/0.002	0.001/0.002	0.001/0.002	0.001/0.002	0.001/0.002	0.001/0.002
		Rod to Crankpin Wear Limit	0.003	0.0025	0.0025	0.0025	0.0025	0.0025	0.0025
		Rod to Piston Pin (New)	0.0007/0.0008	0.0006/0.0011	0.0006/0.0011	0.0003/0.0008	0.0003/0.0008	0.0003/0.0008	0.0003/0.0008
	Small End I.D. (New)		0.5630/0.5633	0.6255/0.6258	0.6255/0.6258	0.8596/0.8599	0.8757/0.8760	0.8757/0.8760	0.8757/0.8760
Crankshaft	Main PTO & Flywheel End O.D.	New	0.9841/0.9844	1.1811/1.1814	1.1811/1.1814	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749
		Max. Wear Limit	0.9841	1.1811	1.1811	1.5745	1.5745	1.5745	1.5745
	CRANKPIN	New	0.9360/0.9355	1.1860/1.1855	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995
		Max. Wear Limit	0.9350	1.1850	1.1850	1.4990	1.4990	1.4990	1.4990
		Max. Out of Round	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005	0.0005
		Max. Taper	0.001	0.001	0.001	0.001	0.001	0.001	0.001
	End Play		0.004/0.023	0.002/0.023	0.002/0.023	0.003/0.020	0.003/0.020	0.003/0.020	0.003/0.020
Cylinder Bore	Inside Diameter	New	2.3755/2.3745	2.9380/2.9370	2.9380/2.9370	3.2515/3.2505	3.3755/3.3745	3.5005/3.4995	3.7505/3.7495
		Max. Wear Limit	2.378	2.941	2.941	3.254	3.378	3.503	3.753
	Max. Out of Round		0.003	0.003	0.003	0.003	0.003	0.003	0.003
	Max. Taper		0.003	0.003	0.003	0.002	0.002	0.002	0.002
Cylinder Head	Max. Out of Flatness		0.003	0.003	0.003	0.003	0.003	0.003	0.003
Ignition	Spark Plug Type & Gap	Type (Champion® or equivalent)	RCJ-8	RCJ-8	RCJ-8	RH-10	RH-10	RH-10	RH-10
		Battery	0.025	0.025	0.025	0.035	0.035	0.035	0.035
		Magneto	0.025	0.025	0.025	0.025	0.025	0.025	0.025
		Gaseous Fuels	0.018	0.018	0.018	0.018	0.018	0.018	0.018
	Nominal Point Gap		0.020	0.020	0.020	0.020	0.020	0.020	0.020

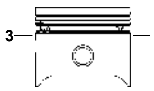
Model (Horsepower)			K91 (4)	K161 (7)	K181 (8)	K241 (10)	K301 (12)	K321 (14)	K341 (16)
All Pistons	Service Replacement Sizes		0.003 – 0.010 – 0.020 – 0.030						
 Piston	Thrust Face O.D.[2]	New	2.371/2.369	2.9297/2.9281	2.9297/2.9281	3.2432/3.2413	3.368/3.365	3.4941/3.4925	3.7425/3.7410
		Max. Wear Limits	2.366	2.925	2.925	3.238	3.363	3.491	3.738
	Thrust Face to Bore Clearance (New)[1]		0.0035/0.006	0.007/0.010	0.007/0.010	0.007/0.010	0.007/0.010	0.007/0.010	0.007/0.010
	Ring End Gap	New Bore	0.007/0.017	0.007/0.017	0.007/0.017	0.010/0.020	0.010/0.020	0.010/0.020	0.010/0.020
		Used Bore (Max.)	0.027	0.027	0.027	0.030	0.030	0.030	0.030
	Max. Ring Side Clearance		0.006	0.006	0.006	0.006	0.006	0.006	0.006
 Piston	Thrust Face O.D.[4]	New	–	–	–	–	–	–	3.7465/3.7455
		Max. Wear Limits	–	–	–	–	–	–	3.744
	Thrust Face to Bore Clearance (New)[1]		–	–	–	–	–	–	0.0030/0.0050
	Ring End Gap	New Bore[5]	–	–	–	–	–	–	0.010/0.020
		Used Bore (Max.)[5]	–	–	–	–	–	–	0.030
	Max. Ring Side Clearance		–	–	–	–	–	–	0.004
 Piston	Thrust Face O.D.[4]	New	–	–	2.9329/2.9336	–	3.3700/3.3693	3.4945/3.4938	3.7433/3.7426
		Max. Wear Limits	–	–	2.931	–	3.367	3.492	3.7406
	Thrust Face to Bore Clearance (New)[1]		–	–	0.0034/0.0051	–	0.0045/0.0062	0.0050/0.0067	0.0062/0.0079
	Ring End Gap	New Bore[5]	–	–	0.010/0.023	–	0.010/0.020	0.010/0.020	0.013/0.025
		Used Bore (Max.)[5]	–	–	0.032	–	0.030	0.030	0.033
	Max. Ring Side Clearance		–	–	0.006	–	0.006	0.006	0.004
Piston Pin	Outside Diameter		0.5623/0.5625	0.6247/0.6249	0.6247/0.6249	0.8591/0.8593	0.8752/0.8754	0.8752/0.8754	0.8752/0.8754
Valves	Guide Reamer Size		0.250	0.3125	0.3125	0.3125	0.3125	0.3125	0.3125
	Tappet Clearance (Cold)	Intake	0.005/0.009	0.006/0.008	0.006/0.008	0.008/0.010	0.008/0.010	0.008/0.010	0.008/0.010 [3]
		Exhaust	0.011/0.015	0.017/0.019	0.017/0.019	0.017/0.019	0.017/0.019	0.017/0.019	0.017/0.019
	Minimum Lift (Zero Lash)	Intake	0.2035	0.2718	0.2718	0.318	0.318	0.318	0.318
		Exhaust	0.1768	0.2482	0.2482	0.318	0.318	0.318	0.318
	Minimum Valve Stem O.D.	Intake	0.2478	0.3103	0.3103	0.3103	0.3103	0.3103	0.3103
		Exhaust	0.2458	0.3088	0.3088	0.3074	0.3074	0.3074	0.3074
	Nominal Angle Valve Seat		45°	45°	45°	45°	45°	45°	45°
	Guide I.D. Max. Wear Limit[1]	Intake	0.005	0.005	0.005	0.006	0.006	0.006	0.006
		Exhaust	0.007	0.007	0.007	0.008	0.008	0.008	0.008

[1]Subtract O.D. of inner part from I.D. of outer part.
[2]Measure just below oil ring groove and at right angles to piston pin.
[3]1800 RPM generator sets .005/.007.
[4]Measure 1/2" above the bottom of the piston skirt.
[5]Top and center compression rings.

K-Series–Twin Cylinder Engine Specifications & Tolerances

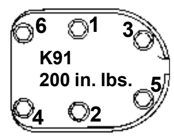
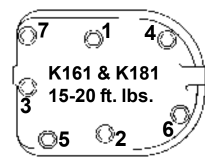
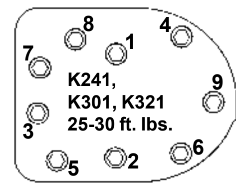
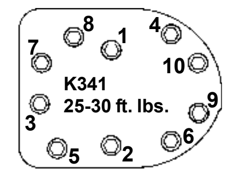
All dimensions in inches.

Model (Horsepower)				KT17 (17)	KT19 (19)	K582 (23)
General	Bore x Stroke			3.125 x 2.750	3.125 x 3.063	3.500 x 3.000
General	Displacement Cu. In.			42.18	47.0	57.73
General	Max. Operating RPM			3600	3600	3600
Camshaft	Sleeve I.D. Installed			–	–	Rear 1.251/1.252 Front 1.876/1.877
Camshaft	End Play			0.003/0.013	0.003/0.013	0.003/0.024
Connecting Rod	Running Clearance	Rod to Crankpin (New)		0.0012/0.0024	0.0012/0.0024	0.001/0.002
Connecting Rod	Running Clearance	Rod to Crankpin Wear Limit		0.0029	0.0029	0.0025
Connecting Rod	Running Clearance	Rod to Piston Pin (New)		0.0006/0.0011	0.0006/0.0011	0.0003/0.0008
Connecting Rod	Small End I.D. (New)			0.6255/0.6258	0.7507/0.7510	0.8757/0.8760
Crankshaft	MAIN	Sleeve Bearing Journal	New	1.7412/1.7422	1.7412/1.7422	1.7495/1.7500
Crankshaft	MAIN	Sleeve Bearing Journal	Wear Limit	1.7407	1.7407	1.7490
Crankshaft	MAIN	Ball/Roller Bearing Journal	New	–	–	1.7716/1.7721
Crankshaft	MAIN	Ball/Roller Bearing Journal	Wear Limit	–	–	1.7711
Crankshaft	MAIN	Max. Out of Round (Sleeve)		0.0005	0.0005	0.0005
Crankshaft	MAIN	Max. Taper (Sleeve)		0.001	0.001	0.001
Crankshaft	MAIN	Running Clearance (Sleeve)	New (Max.)	0.0049	0.0049	0.004
Crankshaft	MAIN	Running Clearance (Sleeve)	Wear Limit[1]	0.0059	0.0059	0.005
Crankshaft	MAIN	New Sleeve Bearing I.D. Installed		1.7439/1.7461	1.7439/1.7461	1.7515/1.7535
Crankshaft	CRANKPIN	New		1.3738/1.3733	1.4998/1.4993 [2]	1.6250/1.6245
Crankshaft	CRANKPIN	Max. Wear Limit		1.3728	1.4988 [2]	1.6240
Crankshaft	CRANKPIN	Max. Out of Round		0.0005	0.0005	0.0005
Crankshaft	CRANKPIN	Max. Taper		0.001	0.001	0.001
Crankshaft	End Play			0.002/0.014	0.002/0.014	0.004/0.010
Cylinder Bore	Inside Diameter	New		3.1255/3.1245	3.1255/3.1245	3.5005/3.4995
Cylinder Bore	Inside Diameter	Max. Wear Limit		3.128	3.128	3.503
Cylinder Bore	Max. Out of Round			0.002	0.002	0.005
Cylinder Bore	Max. Taper			0.0015	0.0015	0.002
Cylinder Head	Max. Out of Flatness			0.003	0.003	0.003

	Model (Horsepower)		KT17 (17)	KT19 (19)	K582 (23)
Ignition	Spark Plug Type & Gap	Type (Champion® or equivalent)	RY17YC	RV17YC	RH-10
		Battery	0.025	0.025	0.025
		Gaseous Fuels	0.018	0.018	0.018
	Nominal Point Gap		0.020	0.020	0.020
 Piston	Service Replacement Sizes		0.003 – 0.010 – 0.020 – 0.030		
	Thrust Face O.D.[3]	New	3.118/3.117	3.121/3.120	3.4941/3.4925
		Max. Wear Limits	3.113	3.113	3.491
	Thrust Face to Bore Clearance (New)[1]		0.0065/0.0085	0.0035/0.0055	0.007/0.010
	Ring End Gap	New Bore	0.010/0.020	0.010/0.020	0.010/0.020
		Used Bore (Max.)	0.030	0.030	0.030
	Max. Ring Side Clearance		0.004	0.004	0.006
 Piston	Service Replacement Sizes		0.003 – 0.010 – 0.020 – 0.030		
	Thrust Face O.D.[4]	New	3.1210/3.1203	3.1215/3.1208	–
		Max. Wear Limits	3.118	3.119	–
	Thrust Face to Bore Clearance (New)[1,4]		0.0035/0.0052	0.0030/0.0047	–
	Ring End Gap	New Bore[5]	0.010/0.020	0.010/0.023	–
		Used Bore (Max.)[5]	0.032	0.032	–
	Max. Ring Side Clearance		0.006	0.006	–
Piston Pin	Outside Diameter		0.6247/0.6249	0.7499/0.7501	0.8752/0.8754
Valves	Guide Reamer Size		0.3125	0.3125	0.3125
	Tappet Clearance (Cold)	Intake	0.003/0.006	0.003/0.006	0.008/0.010
		Exhaust	0.011/0.014	0.011/0.014	0.017/0.020
	Minimum Lift (Zero Lash)	Intake	0.280	0.280	0.318
		Exhaust	0.280	0.280	0.318
	Minimum Valve Stem O.D.	Intake	0.3103	0.3103	0.3103
		Exhaust	0.3088	0.3088	0.3074
	Nominal Angle Valve Seat		45°	45°	45°
	Guide I.D. Max. Wear Limit[1]	Intake	0.005	0.005	0.006
		Exhaust	0.007	0.007	0.008

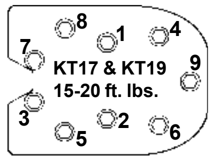
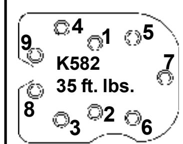
[1]Subtract O.D. of inner part from I.D. of outer part.
[2]Pre Series II 1.3733/1.3738, Maximum Wear 1.3728.
[3]Measure just below oil ring groove and at right angles to piston pin.
[4]Measure 1/2" above the bottom of the piston skirt.
[5]Top and center compression rings.

K-Series–Single Cylinder Torque Values & Sequences for Fasteners

Model (Horsepower)		K91 (4)	K161 (7)	K181 (8)	K241 (10)	K301 (12)	K321 (14)	K341 (16)
Connecting Rods[1]	Posi-Lock[1,2]	–	–	New 140 in. lbs. Used 100 in. lbs.	New 260 in. lbs. Used 200 in. lbs.			
	Capscrew[1,3]	140 in. lbs.	200 in. lbs.		285 in. lbs.			
Spark Plugs		18-22 ft. lbs.	18-22 ft. lbs.		18-22 ft. lbs.			
Cylinder Head[1]					 			
Flywheel Retaining[5]	Nut[1]	40-50 ft. lbs.	85-90 ft. lbs.[4]		50-60 ft. lbs.			
	Screw[1]	250 in. lbs.	–		22-27 ft. lbs.			
Governor Bushing		70-90 in. lbs.	130-150 in. lbs.		100-120 in. lbs.			
Grass Screen	Metal	–	70-140 in. lbs.		70-140 in. lbs.			
	Plastic	–	–		20-30 in. lbs.			
Oil Pan	Cast Iron[1]	250 in. lbs.	Grade 5-250 in. lbs. Grade 8-350 in. lbs.		35 ft. lbs.			
	Sheet Metal[1]	–	–		200 in. lbs.			
Non Metallic Fuel Pump Mounting Screws		–	37-45 in. lbs.		37-45 in. lbs.			

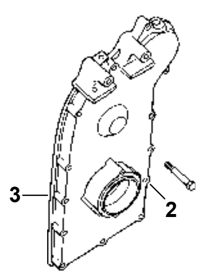
[1]Lubricate fastener threads with engine oil.
[2]DO NOT overtorque – DO NOT loosen and retorque the hex. nuts on Posi-Lock connecting rods.
NEW – Component directly from stock.
USED – Component that was in a running engine.
[3]Overtorque 20%, loosen below torque value and retorque to final torque value.
[4]Prior to Serial No. 23209832 – 45-55 ft. lbs.
[5]Flywheel and crankshaft tapers must be clean and dry.

K-Series–Twin Cylinder Torque Values & Sequences for Fasteners

Model (Horsepower)		KT17 (17)	KT19 (19)	K582 (23)
Connecting Rods[1]	Posi-Lock[1,2]	New 140 in. lbs. Used 100 in. lbs.		–
	Capscrew[1,3]	200 in. lbs.		5/16-200 in. lbs. 3/8-300 in. lbs.
Spark Plugs		10-15 ft. lbs.		18-22 ft. lbs.
Cylinder Head[1]				
Flywheel Retaining	Nut	–		115 ft. lbs.
	Screw[1]	40 ft. lbs.		–
Grass Screen	Metal	70-140 in. lbs.		70-140 in. lbs.
	Plastic	20-30 in. lbs.		–
Oil Pan	Aluminum[1]	–		30 ft. lbs.
	Cast Iron[1]	–		35 ft. lbs.
Manifold Screw/Nut		150 in. lbs.		210 in. lbs.
Camshaft Nut		–		40 ft. lbs.
Non Metallic Fuel Pump Mounting Screws		37-45 in. lbs.		37-45 in. lbs.

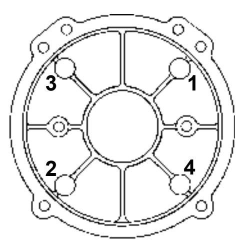
K582

Gear Cover



Install two shoulder capscrews (1/2" thread depth) in second and third holes as indicated. Tighten to 150 in. lbs. – then install other capscrews and torque to 150 in. lbs.

Closure Plate

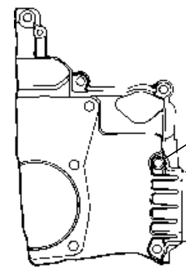


30 ft. lbs.

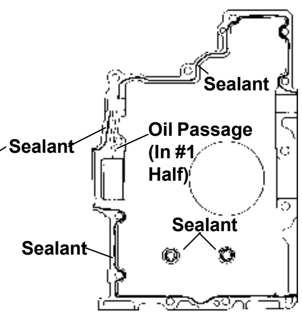
KT17 & KT19

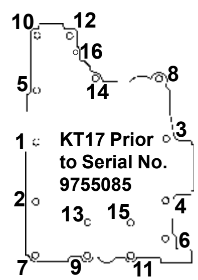
Crankcase

#2 Side Crankcase Half Exterior

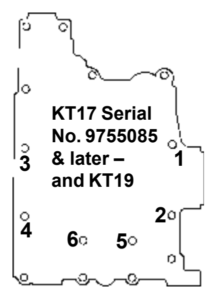


#2 Side Crankcase Half Interior



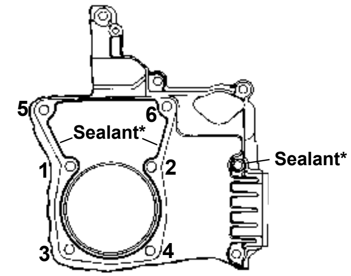


Bolt No.	Torque
1, 2, 3, 4, (12, 14 Grade 8)	260 in. lbs.
5-11, 13, 15	150 in. lbs.
16	35 in. lbs.



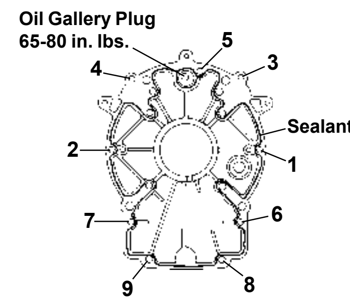
Bolt No.	Torque
1-4	260 in. lbs.
5-6	200 in. lbs.
Torque remaining bolts in most expedient sequence to	200 in. lbs.

Cylinder Barrel



Apply sealant to crankcase.*
Preliminary Torque – 100 in. lbs.
Final Torque – 200 in. lbs.
(Engines with 5/16-18 studs)
Final Torque – 360 in. lbs.
(Engines with 3/8-16 studs)

Closure Plate
150 in. lbs.

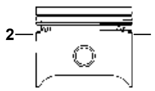
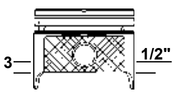
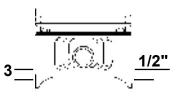


*Use a gasket or sealant as necessary: When reinstalling a closure plate or cylinder barrels originally installed with a gasket, use a new gasket. When reinstalling a closure plate or cylinder barrels originally installed with sealant, use new sealant. When installing a service replacement closure plate or cylinder barrels, use new sealant.

Magnum–Single Cylinder Engine Specifications & Tolerances

All dimensions in inches.

Model (Horsepower)			M8 (8)	M10 (10)	M12 (12)	M14 (14)	M16 (16)
General	Bore x Stroke		2.94 x 2.75	3.25 x 2.88	3.38 x 3.25	3.500 x 3.25	3.750 x 3.25
	Displacement Cu. In.		18.64	23.85	29.07	31.27	35.90
	Max. Operating RPM		3600	3600	3600	3600	3600
Balance Gear	Shaft O.D.	New	–	0.4998/0.5001	0.4998/0.5001	0.4998/0.5001	0.4998/0.5001
		Max. Wear Limit	–	0.4996	0.4996	0.4996	0.4996
	End Play		–	0.002/0.010	0.002/0.010	0.002/0.010	0.002/0.010
Camshaft	End Play		0.005/0.010	0.005/0.010	0.005/0.010	0.005/0.010	0.005/0.010
Connecting Rod	Running Clearance	Rod to Crankpin (New)	0.001/0.002	0.001/0.002	0.001/0.002	0.001/0.002	0.001/0.002
		Rod to Crankpin – Max. Wear Limit	0.0025	0.0025	0.0025	0.0025	0.0025
		Rod to Piston Pin (New)	0.0006/0.0011	0.0003/0.0008	0.0003/0.0008	0.0003/0.0008	0.0003/0.0008
	Small End I.D. (New)		0.6255/0.6258	0.8596/0.8599	0.8757/0.8760	0.8757/0.8760	0.8757/0.8760
Crankshaft	Main PTO & Flywheel End O.D.	New	1.1811/1.1814	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749	1.5745/1.5749
		Max. Wear Limit	1.1811	1.5745	1.5745	1.5745	1.5745
	CRANKPIN	New – O.D.	1.1860/1.1855	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995	1.5000/1.4995
		Max. Wear Limit	1.1850	1.4990	1.4990	1.4990	1.4990
		Max. Out of Round	0.0005	0.0005	0.0005	0.0005	0.0005
		Max. Taper	0.001	0.001	0.001	0.001	0.001
	End Play		0.002/0.023	0.003/0.020	0.003/0.020	0.003/0.020	0.003/0.020
Cylinder Bore	Inside Diameter	New	2.9380/2.9370	3.2515/3.2505	3.3755/3.3745	3.5005/3.4995	3.7505/3.7495
		Max. Wear Limit	2.941	3.254	3.378	3.503	3.753
	Max. Out of Round (I.D.)		0.005	0.005	0.005	0.005	0.005
	Max. Taper (I.D.)		0.003	0.002	0.002	0.002	0.002
Cylinder Head	Max. Out of Flatness		0.003	0.003	0.003	0.003	0.003
Ignition	Spark Plug	Type (Champion® or equivalent)	RCJ-8	RH-10	RH-10	RH-10	RH-10
		Gap	0.025	0.025	0.025	0.025	0.025
	Module Air Gap		0.012/0.016	0.012/0.016	0.012/0.016	0.012/0.016	0.012/0.016

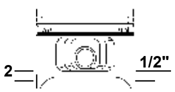
Model (Horsepower)			M8 (8)	M10 (10)	M12 (12)	M14 (14)	M16 (16)
All Pistons	Service Replacement Sizes		0.003 – 0.010 – 0.020 – 0.030				
 Piston	Thrust Face O.D.[2]	New	2.9297/2.9281	3.2432/3.2413	3.368/3.365	3.4941/3.4925	–
		Max. Wear Limits	2.925	3.238	3.363	3.491	–
	Thrust Face to Bore Clearance (New)[1]		0.007/0.010	0.007/0.010	0.007/0.010	0.007/0.010	–
	Ring End Gap	New Bore	0.007/0.017	0.010/0.020	0.010/0.020	0.010/0.020	–
		Used Bore (Max.)	0.027	0.030	0.030	0.030	–
	Max. Ring Side Clearance		0.006	0.006	0.006	0.006	–
 Piston	Thrust Face O.D.[3]	New	–	–	–	–	3.7465/3.7455
		Max. Wear Limits	–	–	–	–	3.7435
	Thrust Face to Bore Clearance (New)[1]		–	–	–	–	0.0030/0.0050
	Ring End Gap	New Bore[4]	–	–	–	–	0.010/0.020
		Used Bore (Max.)[4]	–	–	–	–	0.030
	Max. Ring Side Clearance		–	–	–	–	0.004
 Piston	Thrust Face O.D.[3]	New	2.9329/2.9336	–	3.3700/3.3693	3.4945/3.4938	3.7433/3.7426
		Max. Wear Limits	2.9312	–	3.3673	3.4918	3.7406
	Thrust Face to Bore Clearance (New)[1]		0.0034/0.0051	–	0.0045/0.0062	0.0050/0.0067	0.0062/0.0079
	Ring End Gap	New Bore[4]	0.010/0.023	–	0.010/0.020	0.010/0.020	0.013/0.025
		Used Bore (Max.)[4]	0.032	–	0.030	0.030	0.033
	Max. Ring Side Clearance		0.006	–	0.006	0.006	0.004
Piston Pin	Outside Diameter		0.6247/0.6249	0.8591/0.8593	0.8752/0.8754	0.8752/0.8754	0.8752/0.8754
Valves	Guide Reamer Size		0.3125	0.3125	0.3125	0.3125	0.3125
	Tappet Clearance (Cold)	Intake	0.006/0.008	0.0080/.010	0.008/0.010	0.008/0.010	0.008/0.010
		Exhaust	0.017/0.019	0.017/0.019	0.017/0.019	0.017/0.019	0.017/0.019
	Minimum Lift (Zero Lash)	Intake	0.2718	0.318	0.318	0.318	0.318
		Exhaust	0.2482	0.318	0.318	0.318	0.318
	Minimum Valve Stem O.D.	Intake	0.3103	0.3103	0.3103	0.3103	0.3103
		Exhaust	0.3074	0.3074	0.3074	0.3074	0.3074
	Nominal Angle Valve Seat		45°	45°	45°	45°	45°
	Guide I.D. Max. Wear Limit[1]	Intake	0.006	0.006	0.006	0.006	0.006
		Exhaust	0.008	0.008	0.008	0.008	0.008

[1]Subtract O.D. of inner part from I.D. of outer part.
[2]Measure just below oil ring and at right angles to piston pin.
[3]Measure 1/2" above the bottom of the piston skirt.
[4]Top and center compression rings.

Magnum–Twin Cylinder Engine Specifications & Tolerances

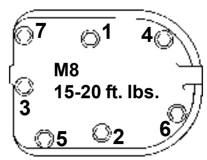
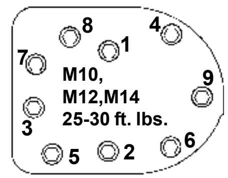
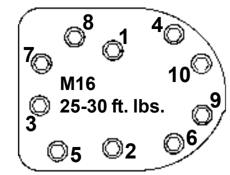
All dimensions in inches.

Model (Horsepower)				MV16 (16)	M18 & MV18 (18)	M20 & MV20 (20)
General	Bore x Stroke			3.125 x 2.750	3.125 x 2.750	3.125 x 3.062
	Displacement Cu. In.			42.18	42.18	46.98
	Max. Operating RPM			3600	3600	3600
Camshaft	End Play			0.003/0.013	0.003/0.013	0.003/0.013
Connecting Rod	Running Clearance	Rod to Crankpin (New)		0.0012/0.0024	0.0012/0.0024	0.0012/0.0024
		Rod to Crankpin Wear Limit		0.0029	0.0029	0.0029
		Rod to Piston Pin (New)		0.0006/0.0011	0.0006/0.0011	0.0006/0.0011
	Small End I.D. (New)			0.6255/0.6258	0.6255/0.6258	0.7507/0.7510
Crankshaft	MAIN	PTO & Flywheel End O.D.	New	1.7412/1.7422	1.7412/1.7422	1.7412/1.7422
			Max. Wear Limit	1.7407	1.7407	1.7407
		Max. Out of Round (Sleeve)		0.0005	0.0005	0.0005
		Max. Taper (Sleeve)		0.001	0.001	0.001
		Running Clearance (Sleeve)	Max. New	0.0049	0.0049	0.0049
			Wear Limit[1]	0.0059	0.0059	0.0059
		New Sleeve Bearing I.D. Installed		1.7439/1.7461	1.7439/1.7461	1.7439/1.7461
	CRANKPIN	New		1.3738/1.3733	1.3738/1.3733	1.4998/1.4993
		Max. Wear Limit		1.3728	1.3728	1.4988
		Max. Out of Round		0.0005	0.0005	0.0005
		Max. Taper		0.001	0.001	0.001
	End Play			0.002/0.014	0.002/0.014	0.002/0.014
Cylinder Bore	Inside Diameter	New		3.1255/3.1245	3.1255/3.1245	3.1255/3.1245
		Max. Wear Limit		3.128	3.128	3.128
	Max. Out of Round			0.002	0.002	0.002
	Max. Taper			0.0015	0.0015	0.0015
Cylinder Head	Max. Out of Flatness			0.003	0.003	0.003
Ignition	Spark Plug	Type (Champion® or equivalent)		RV17C	RV17C	RV17C
		Gap		0.035	0.035	0.035
	Module Air Gap			0.008/0.012	0.008/0.012	0.008/0.012

Model (Horsepower)				MV16 (16)	M18 & MV18 (18)	M20 & MV20 (20)
Piston 	Service Replacement Sizes			0.003 – 0.010 – 0.020 – 0.030		
	Thrust Face O.D.[2]	New		3.1210/3.1203	3.1210/3.1203	3.1215/3.1208
		Max. Wear Limits		3.1181	3.1181	3.1186
	Thrust Face to Bore Clearance (New)[1]			0.0035/0.0052	0.0035/0.0052	0.0030/0.0047
	Ring End Gap	New Bore[3]		0.010/0.023	0.010/0.023	0.010/0.023
		Used Bore (Max.)[3]		0.032	0.032	0.032
	Max. Ring Side Clearance			0.006	0.006	0.006
Piston Pin	Outside Diameter			0.6247/0.6249	0.6247/0.6249	0.7499/0.7501
Valves	Guide Reamer Size			0.3125	0.3125	0.3125
	Tappet Clearance (Cold)	Intake		0.003/0.006	0.003/0.006	0.003/0.006
		Exhaust	Before Serial No. 181600646	0.016/0.019	0.016/0.019	0.016/0.019
			Serial No. 18100656 to 1917809296	0.011/0.014	0.011/0.014	0.011/0.014
			After Serial No. 1917809296	0.013/0.016	0.013/0.016	0.013/0.016
	Minimum Lift (Zero Lash)	Intake		0.274	0.274	0.274
		Exhaust		0.274	0.274	0.274
	Minimum Valve Stem O.D.	Intake		0.3103	0.3103	0.3103
		Exhaust		0.3088	0.3088	0.3088
	Nominal Angle – Valve Seat	Serial No. 1816500646 & earlier		45°	45°	45°
		Serial No. 181650056 & later		30°	30°	30°
	Guide I.D. Max. Wear Limit[1]	Intake		0.005	0.005	0.005
		Exhaust		0.007	0.007	0.007

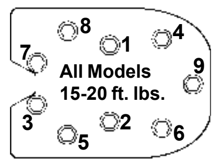
[1]Subtract O.D. of inner part from I.D. of outer part.
[2]Measure 1/2" above the bottom of the piston skirt.
[3]Top and center compression rings.

Magnum–Single Cylinder Torque Values & Sequences for Fasteners

Model (Horsepower)		M8 (8)	M10 (10)	M12 (12)	M14 (14)	M16 (16)
Connecting Rods[1,2]	New	140 in. lbs.	260 in. lbs.			
	Used	100 in. lbs.	200 in. lbs.			
Spark Plugs		18-22 ft. lbs.	18-22 ft. lbs.			
Cylinder Head[1]						
Flywheel[5]	Screw[1]	–	35-40 ft. lbs.			
	Nut[1]	85-90 ft. lbs.	–			
	Fan	115 in. lbs.	115 in. lbs.			
Governor	Anti-Lock	15 in. lbs.	–			
	Bushing	100-120 in. lbs.	100-120 in. lbs.			
Non Metallic Fuel Pump Mounting Screws		37-45 in. lbs.	37-45 in. lbs.			
Ignition Module		32 in. lbs.	32 in. lbs.			
Cam Gear Cover		–	115 in. lbs.			
Key Switch Nut		–	90-100 in. lbs.			
Fuel Tank	Isolation Mount	Hand Tight (2-12 in. lbs.)	Hand Tight (2-12 in. lbs.)			
	Bracket[3]	150 in. lbs.	–			
	Mounting	90 in. lbs.	–			
Speed Control Wing/Hex. Nut	Remote[4]	10-15 in. lbs.	10-15 in. lbs.			
	Local	15-25 in. lbs.	15-25 in. lbs.			

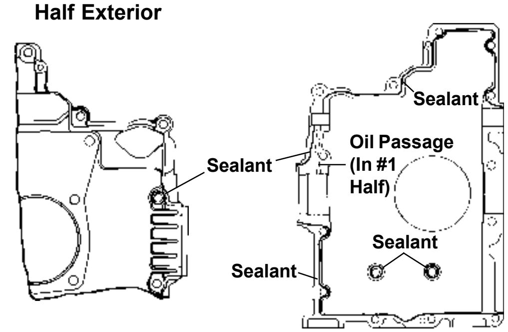
[1]Lubricate fastener threads with engine oil.
[2]DO NOT overtorque – DO NOT loosen and retorque the hex. nuts on Posi-Lock connecting rods.
NEW – Component directly from stock.
USED – Component that was in a running engine.
[3]To cylinder head, electric start side.
[4]Torque, then loosen 1/2 turn.
[5]Flywheel and crankshaft tapers must be clean and dry.

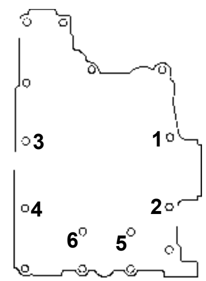
Magnum–Twin Cylinder Torque Values & Sequences for Fasteners

Model (Horsepower)		MV16 (16)	M18 & MV18 (18)	M20 & MV20 (20)
Connecting Rods[1,2]	New	140 in. lbs.		
	Used	100 in. lbs.		
Spark Plugs		10-15 ft. lbs.		
Cylinder Head[1]				
Flywheel[5]	Screw[1]	40 ft. lbs.		
	Fan	115 in. lbs.		
Manifold Screw/Nut		150 in. lbs.		
Non Metallic Fuel Pump Mounting Screws		37-45 in. lbs.		
Ignition Module		32 in. lbs.		
Oil Filter		Snug Plus 1/2 Turn (50/80 in. lbs.)		
Remote Oil Filter	Lines	65-80 in. lbs.		
	Oil Line Flared Nuts	100-120 in. lbs.		
	Adapter	125 in. lbs.		
	Adapter Fittings	90-130 in. lbs.		
	Cover Plate	125 in. lbs.		

Twin Cylinder Engines

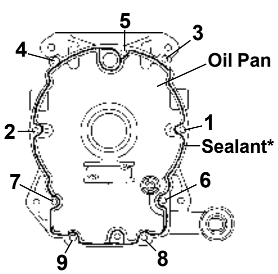
Crankcase (All)





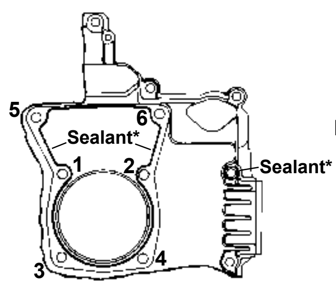
Bolt No.	Torque
1-4	260 in. lbs.
5-6	200 in. lbs.
Torque remaining bolts in most expedient sequence to	200 in. lbs.

Oil Pan (MV16, MV18, MV20)
150 in. lbs.



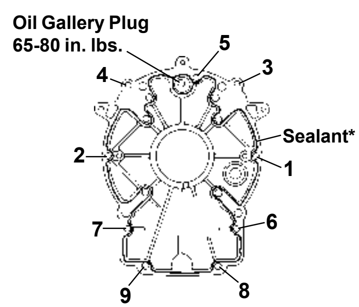
NOTE: Do not use gasket on MV oil pans.

Cylinder Barrel (All)



Apply sealant to crankcase.*
Preliminary Torque – 100 in. lbs.
Final Torque – 200 in. lbs.
(Engines with 5/16-18 studs)
Final Torque – 360 in. lbs.
(Engines with 3/8-16 studs)

Closure Plate (M18 & M20)
150 in. lbs.

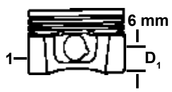


*Use a gasket or sealant as necessary: When reinstalling a closure plate or cylinder barrels originally installed with a gasket, use a new gasket. When reinstalling a closure plate or cylinder barrels originally installed with sealant, use new sealant. When installing a service replacement closure plate or cylinder barrels, use new sealant.

Command–Single Cylinder Engine Specifications & Tolerances

All dimensions in millimeters (inches).

Model (Horsepower)			CH5 (5)	CH6 (6)
General	Kilowatt (kW) Output (@ 3600 RPM – net rating per SAE J1349)		3.73	4.47*
	Horsepower (@ 3600 RPM – net rating per SAE J1349)		5.0	6.0*
	Bore		67 (2.64)	
	Stroke		51 (2.01)	
	Displacement		180 cm³ (10.98 in.³)	
Camshaft	End Play (With Shims)		0.15/0.55 (0.005/0.0217)	
	Bore I.D. Max. Wear Limit	In Crankcase	16.030 (0.6311)	
		In Closure Plate	25.430 (1.001)	
	Camshaft Bearing Surface O.D. – Max. Wear Limit	Crankcase End	15.954 (0.6281)	
		Closure Plate End	25.350 (0.9980)	
Connecting Rod	Connecting Rod to Crankpin Running Clearance – New		0.030/0.056 (0.0012/0.0022)	
	Connecting Rod to Crankpin Running Clearance – Max. Wear Limit		0.0635 (0.0025)	
Crankshaft	End Play (Free)		0.000/0.056 (0.000/0.0022)	
	Crankshaft Bore to Crankshaft Running Clearance – New (Sleeve Bearing)		–	0.02/0.09 (0.0008/0.0036)
	Crankshaft Bore to Crankshaft Running Clearance – Max. Wear Limit		–	0.115 (0.0046)
	Flywheel End Main Bearing Journal	O.D. – New	–	30.000/30.008 (1.20/1.2003)
		O.D. – Max. Wear Limit	–	29.95 (1.198)
		Max. Taper	–	0.020 (0.0008)
		Max. Out of Round	–	0.025 (0.0010)
	PTO End Main Bearing Journal	O.D. – New	–	29.971/29.980 (1.988/1.992)
		O.D. – Max. Wear Limit	–	29.93 (1.1972)
		Max. Taper	–	0.020 (0.0008)
		Max. Out of Round	–	0.025 (0.0010)
	Connecting Rod Journal	O.D. – New	30.947/30.960 (1.2184/1.2189)	
		O.D. – Max. Wear Limit	30.934 (1.2179)	
		Max. Taper	0.025 (0.0010)	
		Max. Out of Round	0.013 (0.0005)	
Cylinder Bore	Cylinder Bore I.D.	New	67.00/67.03 (2.6378/2.6390)	
		Max. Wear Limit	67.049 (2.6397)	
		Max. Out of Round	0.150 (0.0059)	
		Max. Taper	0.100 (0.0039)	
Cylinder Head	Max. Out of Flatness		0.076 (0.003)	
Governor	Governor Cross Shaft O.D. – Max. Wear Limit		6.296 (0.2479)	
	Governor Gear Shaft O.D. – Max. Wear Limit		9.960 (0.3921)	
	Governor Cross Shaft Bore (In Crankcase) I.D. – Max. Wear Limit		6.425 (0.2530)	

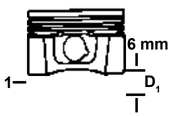
<table>
<tr><th colspan="3">Model (Horsepower)</th><th>CH5 (5)</th><th>CH6 (6)</th></tr>
<tr><td rowspan="3">Ignition</td><td colspan="2">Spark Plug Type (Champion® or equivalent)</td><td colspan="2">RC12YC</td></tr>
<tr><td colspan="2">Spark Plug Gap</td><td colspan="2">1.02 (0.040)</td></tr>
<tr><td colspan="2">Ignition Module Air Gap</td><td colspan="2">0.203/0.305 (0.008/0.012)</td></tr>
<tr><td rowspan="8">Pistons, Piston Rings, and Piston Pin</td><td colspan="2">Top Compression Ring to Groove Side Clearance</td><td colspan="2">0.040/0.085 (0.0016/0.033)</td></tr>
<tr><td colspan="2">Middle Compression Ring to Groove Side Clearance</td><td colspan="2">0.040/0.072 (0.0016/0.0028)</td></tr>
<tr><td colspan="2">Oil Control Ring to Groove Side Clearance</td><td colspan="2">0.140/0.275 (0.0055/0.0108)</td></tr>
<tr><td rowspan="2">Piston Ring End Gap</td><td>New Bore</td><td colspan="2">0.25/0.45 (0.010/0.018)</td></tr>
<tr><td>Used Bore (Max.)</td><td colspan="2">0.75 (0.030)</td></tr>
<tr><td rowspan="3">Piston Thrust Face[1] (@D_1) to Cylinder Bore</td><td>O.D. – New</td><td colspan="2">66.941/66.959 (2.635/2.636)</td></tr>
<tr><td>O.D. – Max. Wear Limit</td><td colspan="2">66.816 (2.630)</td></tr>
<tr><td>New – Running Clearance</td><td colspan="2">0.016/0.059 (0.0006/0.0023)</td></tr>
<tr><td rowspan="9">Valves and Valve Lifters</td><td colspan="2">Intake Valve to Tappet Cold Clearance</td><td colspan="2">0.000/0.0508 (0.000/0.0020)</td></tr>
<tr><td colspan="2">Exhaust Valve to Tappet Cold Clearance</td><td colspan="2">0.000/0.508 (0.000/0.0020)</td></tr>
<tr><td rowspan="2">Intake Valve Guide</td><td>I.D. – Std.</td><td colspan="2">4.990/5.010 (0.1965/0.1972)</td></tr>
<tr><td>I.D. – Max. Wear Limit</td><td colspan="2">5.085 (0.2002)</td></tr>
<tr><td rowspan="2">Exhaust Valve Guide</td><td>I.D. – Std.</td><td colspan="2">4.990/5.010 (0.1965/0.1972)</td></tr>
<tr><td>I.D. – Max. Wear Limit</td><td colspan="2">5.080 (0.2000)</td></tr>
<tr><td colspan="2">Intake Valve Minimum Lift</td><td colspan="2">5.4 (0.213)</td></tr>
<tr><td colspan="2">Exhaust Valve Minimum Lift</td><td colspan="2">5.4 (0.213)</td></tr>
<tr><td colspan="2">Nominal Valve Seat Angle</td><td colspan="2">45°</td></tr>
</table>

* @ 4000 RPM (Gross rating per SAE J1995).
[1]Measure 6 mm above the bottom of piston skirt at right angles to piston pin.

Command–Single Cylinder Engine Specifications & Tolerances

All dimensions in millimeters (inches).

Model (Horsepower)			CH & CV11 (11)	CH & CV12.5 (12.5)	CH & CV13 (13)	CH & CV14 (14)
General	Kilowatt (kW) Output (@ 3600 RPM – SAE J1995)		8.20	9.33	9.75	10.50
	Horsepower (@ 3600 RPM – SAE J1995)		11	12.5	13	14
	Bore		87 (3.43)			
	Stroke		67 (2.64)			
	Displacement		398 cm³ (24.3 in.³)			
Balance Shaft Bearing	End Play (Free)		0.0575/0.3625 (0.0023/0.0143)			
	Bore I.D. (In Crankcase and Oil Pan, Max. Wear Limit)		20.038 (0.7889)			
	Balance Shaft Bearing Surface O.D. Max. Wear Limit		19.959 (0.7858)			
Camshaft	End Play		With Shims – 0.076/0.127 (0.003/0.005) Without Shims – 0.10/0.39 (0.004/0.015)			
	Bore I.D. Max. Wear Limit	In Crankcase	20.038 (0.7889)			
		In Oil Pan	20.038 (0.7889)			
	Camshaft Bearing Surface O.D. – Max. Wear Limit	Crankcase End	19.959 (0.7858)			
		Oil Pan End	19.959 (0.7858)			
Connecting Rod	Connecting Rod to Crankpin Running Clearance	New	0.030/0.055 (0.0012/0.0022)			
		Max. Wear Limit	0.07 (0.0025)			
Crankshaft	End Play (Free)		0.0575/0.4925 (0.0023/0.0194)			
	Crankshaft Sleeve Bearing I.D. – Max. Wear Limit		45.016 (1.7723)			
	Crankshaft PTO Bearing	I.D. – New Installed	44.965/45.003 (1.7703/1.7718)			
		Max. Wear Limit	45.016 (1.7723)			
	Crankshaft Bore to Crankshaft Running Clearance	New	0.03/0.09 (0.0012/0.0035)			
		Max. Wear Limit	0.115 (0.0045)			
	Flywheel End Main Bearing Journal	O.D. – New	44.913/44.935 (1.7582/1.7691)			
		O.D. – Max. Wear Limit	45.016 (1.7723)			
		Max. Taper	0.022 (0.0009)			
		Max. Out of Round	0.025 (0.0010)			
	PTO End Main Bearing Journal	O.D. – New	41.915/41.935 (1.6502/1.6510)			
		O.D. – Max. Wear Limit	41.86 (1.648)			
		Max. Taper	0.020 (0.0008)			
		Max. Out of Round	0.025 (0.0010)			
	Connecting Rod Journal	O.D. – New	38.958/38.970 (1.5338/1.5343)			
		O.D. – Max. Wear Limit	38.94 (1.5328)			
		Max. Taper	0.012 (0.0005)			
		Max. Out of Round	0.025 (0.0010)			

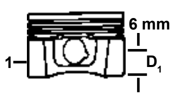
Model (Horsepower)			CH & CV11 (11)	CH & CV12.5 (12.5)	CH & CV13 (13)	CH & CV14 (14)
Cylinder Bore	Cylinder Bore I.D.	New	87.000/87.025 (3.4252/3.4262)			
		Max. Wear Limit	87.063 (3.4277)			
		Max. Out of Round	0.12 (0.0047)			
		Max. Taper	0.05 (0.0020)			
Cylinder Head	Max. Out of Flatness		0.076 (0.003)			
Governor	Governor Cross Shaft O.D. – Max. Wear Limit		5.962 (0.2347)			
	Governor Gear Shaft O.D. – Max. Wear Limit		5.977 (0.2353)			
	Governor Cross Shaft Bore (In Crankcase) I.D. – Max. Wear Limit		6.063 (0.2387)			
Ignition	Spark Plug Type (Champion® or equivalent)		RC12YC			
	Spark Plug Gap		1.02 (0.040)			
	Ignition Module Air Gap		0.203/0.305 (0.008/0.012)			
 Pistons, Piston Rings, and Piston Pin	Top Compression Ring to Groove Side Clearance		0.040/0.105 (0.0016/0.0041)			
	Middle Compression Ring to Groove Side Clearance		0.040/0.072 (0.0016/0.0028)			
	Oil Control Ring to Groove Side Clearance		0.55/0.675 (0.0217/0.0266)			
	Piston Ring End Gap	New Bore	0.3/0.5 (0.012/0.020)			
		Used Bore (Max.)	0.77 (0.030)			
	Piston Thrust Face[1] (@D_1) to Cylinder Bore	O.D. – New	86.941/86.959 (3.4229/3.4236)			
		O.D. – Max. Wear Limit	86.814 (3.4179)			
		New – Running Clearance	0.041/0.044 (0.0016/0.0017)			
Valves and Valve Lifters	Intake Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2778)			
		I.D. – Max. Wear Limit	7.134 (0.2809)			
	Exhaust Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)			
		I.D. – Max. Wear Limit	7.159 (0.2819)			
	Intake Valve Minimum Lift		8.96 (0.353)			
	Exhaust Valve Minimum Lift		9.14 (0.360)			
	Rocker Arm I.D. – Max. Wear Limit		16.13 (0.640)			
	Rocker Shaft O.D. – Max. Wear Limit		15.727 (0.619)			
	Nominal Valve Seat Angle		45°			
	Hydraulic Lifter to Crankcase Running Clearance		0.0124/0.0501 (0.0005/0.0020)			
	Intake Valve Stem to Valve Guide Running Clearance		0.038/0.076 (0.0015/0.0030)			
	Exhaust Valve Stem to Valve Guide Running Clearance		0.050/0.088 (0.0020/0.0035)			

[1]Measure 6 mm above the bottom of piston skirt at right angles to piston pin.

Command–Single Cylinder Engine Specifications & Tolerances

All dimensions in millimeters (inches).

Model (Horsepower)			CH & CV15 (15)
General	Kilowatt (kW) Output (@ 3600 RPM – SAE J1995)		11.2
	Horsepower (@ 3600 RPM – SAE J1995)		15
	Bore		90 (3.60)
	Stroke		67 (2.64)
	Displacement		426 cc (26.0 cu. in.)
Balance Shaft Bearing	End Play (Free)		0.0575/0.3625 (0.0023/0.0143)
	Bore I.D. (In Crankcase and Oil Pan, Max. Wear Limit)		20.038 (0.7889)
	Balance Shaft Bearing Surface O.D. Max. Wear Limit		19.959 (0.7858)
Camshaft	End Play		With Shims – 0.076/0.127 (0.003/0.005) Without Shims – 0.10/0.39 (0.004/0.015)
	Bore I.D. Max. Wear Limit	In Crankcase	20.038 (0.7889)
		In Oil Pan	20.038 (0.7889)
	Camshaft Bearing Surface O.D. – Max. Wear Limit	Crankcase End	19.959 (0.7858)
		Oil Pan End	19.959 (0.7858)
Connecting Rod	Connecting Rod to Crankpin Running Clearance	New	0.030/0.055 (0.0012/0.0022)
		Max. Wear Limit	0.07 (0.0025)
Crankshaft	End Play (Free)		0.0575/0.4925 (0.0023/0.0194)
	Crankshaft Sleeve Bearing I.D. – Max. Wear Limit		45.016 (1.7723)
	Crankshaft PTO Bearing	I.D. – New Installed	44.965/45.003 (1.7703/1.7718)
		Max. Wear Limit	45.016 (1.7723)
	Crankshaft Bore to Crankshaft Running Clearance	New	0.03/0.09 (0.0012/0.0035)
		Max. Wear Limit	0.115 (0.0045)
	Flywheel End Main Bearing	O.D. – New	44.913/44.935 (1.7582/1.7691)
		O.D. – Max. Wear Limit	44.84 (1.765)
		Max. Taper	0.022 (0.0009)
		Max. Out of Round	0.025 (0.0010)
	Closure Plate or Oil Pan End Main Bearing	O.D. – New	41.915/41.935 (1.6502/1.6510)
		O.D. – Max. Wear Limit	41.86 (1.648)
		Max. Taper	0.020 (0.0008)
		Max. Out of Round	0.025 (0.0010)
	Connecting Rod Journal	O.D. – New	38.958/38.970 (1.5338/1.5343)
		O.D. – Max. Wear Limit	38.94 (1.5328)
		Max. Taper	0.012 (0.0005)
		Max. Out of Round	0.025 (0.0010)

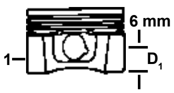
Model (Horsepower)			CH & CV15 (15)
Cylinder Bore	Cylinder Bore I.D.	New	90.000/90.025 (3.5433/3.5443)
		Max. Wear Limit	90.063 (3.5457)
		Max. Out of Round	0.12 (0.0047)
		Max. Taper	0.05 (0.0020)
Cylinder Head	Max. Out of Flatness		0.076 (0.003)
Governor	Governor Cross Shaft O.D. – Max. Wear Limit		5.962 (0.2347)
	Governor Gear Shaft O.D. – Max. Wear Limit		5.977 (0.2353)
	Governor Cross Shaft Bore (In Crankcase) I.D. – Max. Wear Limit		6.063 (0.2387)
Ignition	Spark Plug Type (Champion® or equivalent)		RC12YC
	Spark Plug Gap		1.02 (0.040)
	Ignition Module Air Gap		0.203/0.305 (0.008/0.012)
 Pistons, Piston Rings, and Piston Pin	Top Compression Ring to Groove Side Clearance		0.060/0.105 (0.0023/0.0041)
	Middle Compression Ring to Groove Side Clearance		0.040/0.085 (0.0015/0.0002)
	Oil Control Ring to Groove Side Clearance		0.176/0.026 (0.0069/0.0010)
	Piston Ring End Gap	New Bore	0.27/0.51 (0.010/0.020)
		Used Bore (Max.)	0.77 (0.030)
	Piston Thrust Face[1] (@D_1) to Cylinder Bore	O.D. – New	89.951/89.969 (3.5413/3.5420)
		O.D. – Max. Wear Limit	89.824 (3.5363)
		New – Running Clearance	0.031/0.043 (0.0012/0.0016)
Valves and Valve Lifters	Intake Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2778)
		I.D. – Max. Wear Limit	7.134 (0.2809)
	Exhaust Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)
		I.D. – Max. Wear Limit	7.159 (0.2819)
	Intake Valve Minimum Lift		8.96 (0.353)
	Exhaust Valve Minimum Lift		9.14 (0.360)
	Rocker Arm I.D. – Max. Wear Limit		16.13 (0.640)
	Rocker Shaft O.D. – Max. Wear Limit		15.727 (0.619)
	Nominal Valve Seat Angle		45°
	Hydraulic Lifter to Crankcase Running Clearance		0.0124/0.0501 (0.0005/0.0020)
	Intake Valve Stem to Valve Guide Running Clearance		0.038/0.076 (0.0015/0.0030)
	Exhaust Valve Stem to Valve Guide Running Clearance		0.050/0.088 (0.0020/0.0035)

[1]Measure 6 mm above the bottom of piston skirt at right angles to piston pin.

Command–Twin Cylinder Engine Specifications & Tolerances

All dimensions in millimeters (inches).

Model (Horsepower)			CH & CV18 (18)	CH & CV20 (20)	CH & CV22 (22)
General	Kilowatt (kW) Output (@ 3600 RPM – SAE J1995)		13.4	14.9	16.4
	Horsepower (@ 3600 RPM – SAE J1995)		18	20	22
	Bore		77 (3.03)		
	Stroke		67 (2.64)		
	Displacement		624 cm³ (38.1 in.³)		
Camshaft	End Play (With Shims)		0.076/0.127 (0.003/0.005)		
	Bore I.D. Max. Wear Limit	In Crankcase	20.038 (0.7889)		
	Camshaft Bearing Surface O.D. – Max. Wear Limit	Oil Pan End	19.959 (0.7858)		
Connecting Rod	Connecting Rod to Crankpin Running Clearance	New	0.030/0.055 (0.0012/0.0022)		
		Max. Wear Limit	0.07 (0.0025)		
Crankshaft	End Play (Free)		0.070/0.480 (0.0028/0.0189)		
	Crankshaft Main Bearing I.D. – Max. Wear Limit		41.016 (1.6148)		
	Crankshaft to Sleeve Bearing Running Clearance – New (Early CH models only.)		0.03/0.09 (0.0012/0.0035)		
	Crankshaft Bore to Crankshaft Running Clearance – New		0.039/0.074 (0.0015/0.0029)		
	Main Bearing Journals	O.D. – New	40.913/40.935 (1.6107/1.6116)		
		O.D. – Max. Wear Limit	40.84 (1.608)		
		Max. Taper	0.022 (0.0009)		
		Max. Out of Round	0.025 (0.0010)		
	Connecting Rod Journal	O.D. – New	35.955/35.973 (1.4156/1.4163)		
		O.D. – Max. Wear Limit	35.94 (1.415)		
		Max. Taper	0.018 (0.0007)		
		Max. Out of Round	0.025 (0.0010)		
Cylinder Bore	Cylinder Bore I.D.	New	77.000/77.015 (3.0315/3.0325)		
		Max. Wear Limit	77.063 (3.0340)		
		Max. Out of Round	0.12 (0.0047)		
		Max. Taper	0.05 (0.0020)		
Cylinder Head	Max. Out of Flatness		0.076 (0.003)		
Governor	Governor Cross Shaft O.D. – Max. Wear Limit		5.962 (0.2347)		
	Governor Gear Shaft O.D. – Max. Wear Limit		5.977 (0.2353)		
	Governor Cross Shaft Bore (In Crankcase) I.D. – Max. Wear Limit		6.063 (0.2387)		

Model (Horsepower)			CH & CV18 (18)	CH & CV20 (20)	CH & CV22 (22)
Ignition	Spark Plug Type (Champion® or equivalent)		RC12YC		
	Spark Plug Gap		0.76 (0.030)		
	Ignition Module Air Gap		0.28/0.33 (0.011/0.013)		
 Pistons, Piston Rings, and Piston Pin	Top Compression Ring to Groove Side Clearance		0.040/0.080 (0.0016/0.0031)		
	Middle Compression Ring to Groove Side Clearance		0.040/0.072 (0.0016/0.0028)		
	Oil Control Ring to Groove Side Clearance		0.060/0.202 (0.0024/0.0080)		
	Piston Ring End Gap	New Bore	0.25/0.45 (0.0098/0.0177)		
		Used Bore (Max.)	0.77 (0.030)		
	Piston Thrust Face[1] (@D_1) to Cylinder Bore	O.D. – New	76.967/76.985 (3.0302/3.0309)		
		O.D. – Max. Wear Limit	76.840 (3.0252)		
		New – Running Clearance	0.015/0.058 (0.0006/0.0023)		
Valves and Valve Lifters	Intake Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)		
		I.D. – Max. Wear Limit	7.134 (0.2809)		
	Exhaust Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)		
		I.D. – Max. Wear Limit	7.159 (0.2819)		
	Intake Valve Minimum Lift		8.07 (0.3177)		
	Exhaust Valve Minimum Lift		8.07 (0.3177)		
	Nominal Valve Seat Angle		45°		
	Hydraulic Lifter to Crankcase Running Clearance		0.0124/0.0501 (0.0005/0.0020)		
	Intake Valve Stem to Valve Guide Running Clearance		0.038/0.076 (0.0015/0.0030)		
	Exhaust Valve Stem to Valve Guide Running Clearance		0.050/0.088 (0.0020/0.0035)		

[1]Measure 6 mm above the bottom of piston skirt at right angles to piston pin.

Command–Twin Cylinder Engine Specifications & Tolerances

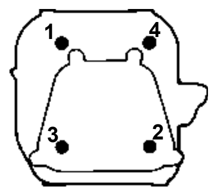
All dimensions in millimeters (inches).

Model (Horsepower)				CH & CV25 (25)
General	Kilowatt (kW) Output (@ 3600 RPM – SAE J1995)			18.6
	Horsepower (@ 3600 RPM – SAE J1995)			25
	Bore			83 (3.27)
	Stroke			67 (2.64)
	Displacement			725 cm³ (44 in.³)
Camshaft	End Play (With Shims)			0.076/0.127 (0.003/0.005)
	Bore I.D. Max. Wear Limit	In Crankcase		20.038 (0.7889)
	Camshaft Bearing Surface O.D. – Max. Wear Limit	Oil Pan End		19.959 (0.7858)
Connecting Rod	Connecting Rod to Crankpin Running Clearance		New	0.030/0.055 (0.0012/0.0022)
			Max. Wear Limit	0.07 (0.0025)
Crankshaft	End Play (Free)			0.070/0.480 (0.0028/0.0189)
	End Play (With Thrust Bearing Components)			0.050/0.5 (0.0020/0.0197)
	End Play (CH25 below Serial No. 2403500008)			0.050/0.75 (0.0020/0.0295)
	Crankshaft Main Bearing I.D. – Max. Wear Limit			41.016 (1.6148)
	Crankshaft to Main Bearing Running Clearance – New			0.03/0.09 (0.0012/0.0035)
	Crankshaft Bore to Crankshaft Running Clearance – New			0.039/0.074 (0.0015/0.0029)
	Main Bearing Journals	O.D. – New		40.913/40.935 (1.6107/1.6116)
		O.D. – Max. Wear Limit		40.84 (1.608)
		Max. Taper		0.022 (0.0009)
		Max. Out of Round		0.025 (0.0010)
	Connecting Rod Journal	O.D. – New		35.955/35.973 (1.4156/1.4163)
		O.D. – Max. Wear Limit		35.94 (1.415)
		Max. Taper		0.018 (0.0007)
		Max. Out of Round		0.025 (0.0010)
Cylinder Bore	Cylinder Bore I.D.	New		82.988/83.013 (3.2672/3.2682)
		Max. Wear Limit		83.051 (3.2697)
		Max. Out of Round		0.12 (0.0047)
		Max. Taper		0.05 (0.0020)
Cylinder Head	Max. Out of Flatness			0.076 (0.003)
Governor	Governor Cross Shaft O.D. – Max. Wear Limit			5.962 (0.2347)
	Governor Gear Shaft O.D. – Max. Wear Limit			5.977 (0.2353)
	Governor Cross Shaft Bore (In Crankcase) I.D. – Max. Wear Limit			6.063 (0.2387)

Model (Horsepower)			CH & CV25 (25)
Ignition	Spark Plug Type (Champion® or equivalent)		RC12YC
	Spark Plug Gap		0.76 (0.030)
	Ignition Module Air Gap		0.28/0.33 (0.011/0.013)
 Pistons, Piston Rings, and Piston Pin	Top Compression Ring to Groove Side Clearance		0.025/0.048 (0.0010/0.0019)
	Middle Compression Ring to Groove Side Clearance		0.015/0.037 (0.0006/0.0015)
	Oil Control Ring to Groove Side Clearance		0.026/0.176 (0.0010/0.0070)
	Piston Ring End Gap	New Bore	0.25/0.56 (0.0100/0.0224)
		Used Bore (Max.)	0.94 (0.037)
	Piston Thrust Face[1] (@D_1) to Cylinder Bore	O.D. – New[1]	82.986 (3.2672)
		O.D. – Max. Wear Limit[1]	82.841 (3.2615)
		New – Running Clearance	0.002/0.045 (0.001/0.0018)
Valves and Valve Lifters	Intake Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)
		I.D. – Max. Wear Limit	7.134 (0.2809)
	Exhaust Valve Guide	I.D. – Std.	7.038/7.058 (0.2771/0.2779)
		I.D. – Max. Wear Limit	7.159 (0.2819)
	Intake Valve Minimum Lift		8.07 (0.3177)
	Exhaust Valve Minimum Lift		8.07 (0.3177)
	Nominal Valve Seat Angle		45°
	Hydraulic Lifter to Crankcase Running Clearance		0.0124/0.0501 (0.0005/0.0020)
	Intake Valve Stem to Valve Guide Running Clearance		0.038/0.076 (0.0015/0.0030)
	Exhaust Valve Stem to Valve Guide Running Clearance		0.050/0.088 (0.0020/0.0035)

[1]Measure 6 mm above the bottom of piston skirt at right angles to piston pin.

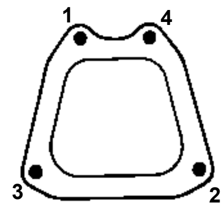
Command–Single Cylinder Torque Values & Sequences for Fasteners

Model (Horsepower)		CH5 (5)	CH6 (6)
Air Cleaner Base Nuts – M6		6.8 N·m (58 in. lb.)	
Carburetor	Fuel Bowl Screw	9.8 N·m (87 in. lb.)	
	Mounting Nuts	6.8 N·m (58 in. lb.)	
Charging Stator Mounting Screw		4.0 N·m (35 in. lb.)	
Connecting Rod Cap Fastener Torque		9.0 N·m (80 in. lb.)	
Closure Plate		22.6 N·m (200 in. lb.)	
Cylinder Head	Fastener	22.6 N·m (200 in. lb.)	
			
	Rocker Studs	13.6 N·m (120 in. lb.)	
Electric Starter Mounting		17/19 N·m (150/170 in. lb.)	
Flywheel Retainer Screw		67.8 N·m (50 ft. lb.)	
Fuel Tank	Fasteners – M6	6.8 N·m (60 in. lb.)	
	Fasteners – M8	17.0 N·m (150 in. lb.)	
Ignition	Spark Plug (14 mm w/gasket)	24.4/29.8 N·m (18/22 ft. lb.)	
	Ignition Module	4.0*/6.2 N·m (35*/55 in. lb.)[1]	
Muffler Retaining Nuts		22.6 N·m (200 in. lb.)	
Oil Sentry™ Switch		13.6 N·m (120 in. lb.)	
Throttle Control Lever		4.3 N·m (38 in. lb.)	
Valve Cover		3.4 N·m (30 in. lb.)	

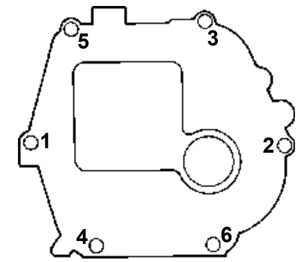
[1]For self-tapping (thread forming) fasteners: The higher torque value is for initial installation into a new cored hole * the lower torque value is for subsequent installation, and installation into tapped holes and weld nuts.

CH5 & CH6

Valve Cover

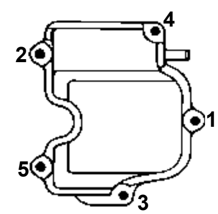


Closure Plate

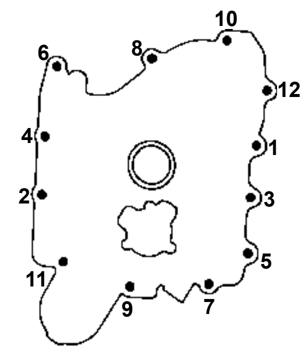


CH11-15 & CV11-15

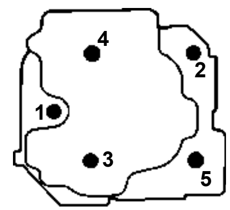
Valve Cover



Closure Plate (CH)/Oil Pan (CV)



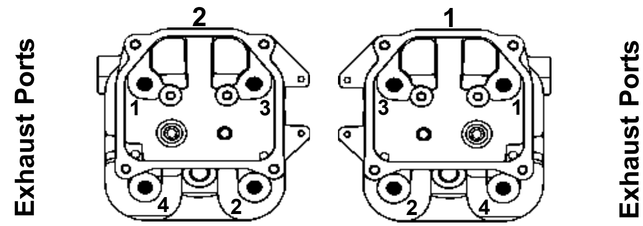
Command–Single Cylinder Torque Values & Sequences for Fasteners

<table>
<tr><th colspan="2">Model (Horsepower)</th><th>CH & CV11 (11)</th><th>CH & CV12.5 (12.5)</th><th>CH & CV13 (13)</th><th>CH & CV14 (14)</th><th>CH & CV15 (15)</th></tr>
<tr><td colspan="2">Air Cleaner Base Nuts – M6</td><td colspan="5">9.9 N·m (88 in. lb.)</td></tr>
<tr><td colspan="2">Carburetor Fuel Bowl Screw</td><td colspan="5">5.1/6.2 N·m (45/55 in. lb.)</td></tr>
<tr><td colspan="2">Charging Stator Mounting Screw</td><td colspan="5">4.0 N·m (35 in. lb.)</td></tr>
<tr><td colspan="2">Connecting Rod Cap Fastener Torque</td><td colspan="5">8mm straight 22.7 N·m (200 in. lb.), 8mm step-down 14.7 N·m (130 in. lb.), 6mm straight 11.3 N·m (100 in. lb.)</td></tr>
<tr><td colspan="2">Closure Plate (CH)/Oil Pan (CV)</td><td colspan="5">24.4 N·m (216 in. lb.)</td></tr>
<tr><td rowspan="3">Cylinder Head</td><td>Fastener</td><td colspan="5">40.7 N·m (30 ft. lb.)[2]</td></tr>
<tr><td></td><td colspan="5">
</td></tr>
<tr><td>Rocker Pedestal (Pivot)</td><td colspan="5">Rocker bridge type 9.9 N·m (88 in. lb.), Guide plate type 11.3 N·m (100 in. lb.)</td></tr>
<tr><td colspan="2">Electric Starter Mounting</td><td colspan="5">15.3 N·m (135 in. lb.)</td></tr>
<tr><td rowspan="2">Flywheel</td><td>Fan Fasteners</td><td colspan="5">9.9 N·m (88 in. lb.)</td></tr>
<tr><td>Retainer Screw</td><td colspan="5">66.4 N·m (49 ft. lb.)</td></tr>
<tr><td colspan="2">Fuel Pump Fasteners</td><td colspan="5">7.3*/9.0 N·m (65*/80 in. lb.)[1]</td></tr>
<tr><td rowspan="2">Ignition</td><td>Spark Plug</td><td colspan="5">38.0/43.4 N·m (28/32 ft. lb.)</td></tr>
<tr><td>Ignition Module</td><td colspan="5">4.0*/6.2 N·m (35*/55 in. lb.)</td></tr>
<tr><td colspan="2">Muffler Retaining Nuts</td><td colspan="5">24.4 N·m (216 in. lb.)</td></tr>
<tr><td rowspan="3">Oil Filter</td><td>Oil Filter</td><td colspan="5">5.7/9.0 N·m (50/80 in. lb.)</td></tr>
<tr><td>Oil Drain Plug (1/8" NPT)</td><td colspan="5">7.3/9.0 N·m (65/80 in. lb.)</td></tr>
<tr><td>Oil Sentry™ Switch</td><td colspan="5">7.9 N·m (70 in. lb.)</td></tr>
<tr><td colspan="2">Oil Pump Cover Fasteners</td><td colspan="5">4.0*/6.2 N·m (35*/55 in. lb.)[1]</td></tr>
<tr><td rowspan="2">Throttle/ Choke Controls</td><td>Governor Control Lever</td><td colspan="5">9.9 N·m (88 in. lb.)</td></tr>
<tr><td>Speed Control Assembly</td><td colspan="5">7.3*/10.7 N·m (65*/95 in. lb.)[1]</td></tr>
<tr><td colspan="2">Valve Cover</td><td colspan="5">7.3*/10.7 N·m (65*/95 in. lb.)</td></tr>
</table>

[1]For self-tapping (thread forming) fasteners: The higher torque value is for initial installation into a new cored hole * the lower torque value is for subsequent installation, and installation into tapped holes and weld nuts.

[2]Tighten in two stages. Torque first to 15 ft. lb. following sequence. Then tighten to final torque value (30 ft. lb.).

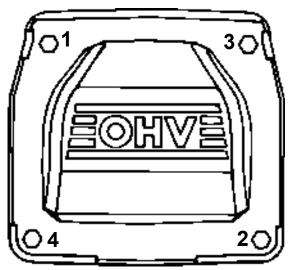
Command–Twin Cylinder Torque Values & Sequences for Fasteners

<table>
<tr><th colspan="2">Model (Horsepower)</th><th>CH & CV18 (18)</th><th>CH & CV20 (20)</th><th>CH & CV22 (22)</th><th>CH & CV25 (25)</th></tr>
<tr><td colspan="2">Breather Plate</td><td colspan="4">7.3 N·m (65 in. lb.)</td></tr>
<tr><td colspan="2">Carburetor Mounting Nuts</td><td colspan="4">9.9 N·m (88 in. lb.)</td></tr>
<tr><td colspan="2">Charging Stator Mounting Screw</td><td colspan="4">4.0 N·m (35 in. lb.)</td></tr>
<tr><td colspan="2">Connecting Rod Cap Fastener Torque</td><td colspan="4">8mm straight 22.7 N·m (200 in. lb.), 8mm step-down 14.7 N·m (130 in. lb.), 6mm straight 11.3 N·m (100 in. lb.)</td></tr>
<tr><td colspan="2">Closure Plate (CH)/Oil Pan (CV)</td><td colspan="4">24.4 N·m (216 in. lb.)</td></tr>
<tr><td rowspan="3">Cylinder Head</td><td>Fastener</td><td colspan="4">Two Step Process; First torque 22.6 N·m (200 in. lb.), Second torque 41.8 N·m (370 in. lb.)</td></tr>
<tr><td></td><td colspan="4">
</td></tr>
<tr><td>Rocker Pedestal (Pivot)</td><td colspan="4">11.3 N·m (100 in. lb.)</td></tr>
<tr><td colspan="2">Electric Starter Mounting</td><td colspan="4">15.3 N·m (135 in. lb.)</td></tr>
<tr><td rowspan="2">Flywheel</td><td>Fan Fasteners</td><td colspan="4">9.9 N·m (88 in. lb.)</td></tr>
<tr><td>Retainer Screw</td><td colspan="4">66.4 N·m (49 ft. lb.)</td></tr>
<tr><td rowspan="2">Ignition</td><td>Spark Plug</td><td colspan="4">24.4/29.8 N·m (18/22 ft. lb.)</td></tr>
<tr><td>Ignition Module</td><td colspan="4">4.0*/6.2 N·m (35*/55 in. lb.)</td></tr>
<tr><td colspan="2">Manifold (Intake)</td><td colspan="4">9.9 N·m (88 in. lb.)</td></tr>
<tr><td colspan="2">Muffler Retaining Nuts</td><td colspan="4">24.4 N·m (216 in. lb.)</td></tr>
<tr><td colspan="2">Rectifier Fasteners</td><td colspan="4">4.0 N·m (35 in. lb.)</td></tr>
<tr><td rowspan="3">Oil Filter</td><td>Oil Filter</td><td colspan="4">5.7/9.0 N·m (50/80 in. lb.)</td></tr>
<tr><td>Oil Drain Plug (1/8" NPT)</td><td colspan="4">13.6 N·m (10 ft. lb.)</td></tr>
<tr><td>Oil Sentry™ Switch</td><td colspan="4">7.9 N·m (70 in. lb.)</td></tr>
<tr><td rowspan="2">Throttle/ Choke Controls</td><td>Governor Control Lever</td><td colspan="4">9.9 N·m (88 in. lb.)</td></tr>
<tr><td>Speed Control Assembly</td><td colspan="4">7.3*/10.7 N·m (65*/95 in. lb.)[1]</td></tr>
<tr><td rowspan="2">Valve Cover</td><td>Gasket/Sealant Type</td><td colspan="4">3.4 N·m (30 in. lb.)</td></tr>
<tr><td>O-Ring Type</td><td colspan="4">7.9 N·m (70 in. lb.)</td></tr>
</table>

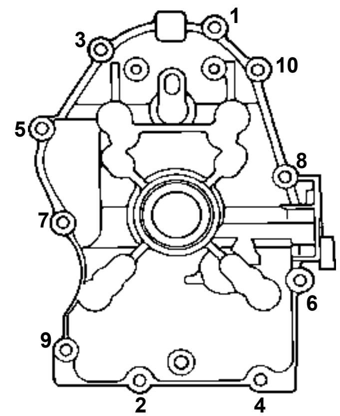
[1]For self-tapping (thread forming) fasteners: The higher torque value is for initial installation into a new cored hole * the lower torque value is for subsequent installation, and installation into tapped holes and weld nuts.

Command–Twin Cylinder Torque Values & Sequences for Fasteners

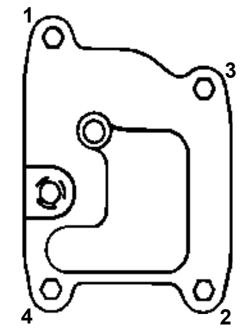
Valve Cover



Closure Plate (CH)/Oil Pan (CV)



Breather Plate



Conversion Factors

Inches x 25.4 = Millimeters (mm)

Inches x 2.54 = Centimeters (cm)

Cubic Inches x 16.387 = Cubic Centimeters (cu cm^3)

Inch Pounds x 0.113 = Newton-meter (N·m)

Foot Pounds x 1.356 = Newton-meter (N·m)

Ounce (Weight) x 28.350 = Grams (g)

Pound x 0.4536 = Kilograms (kg)

Horsepower x 0.746 = Kilowatt (kW)

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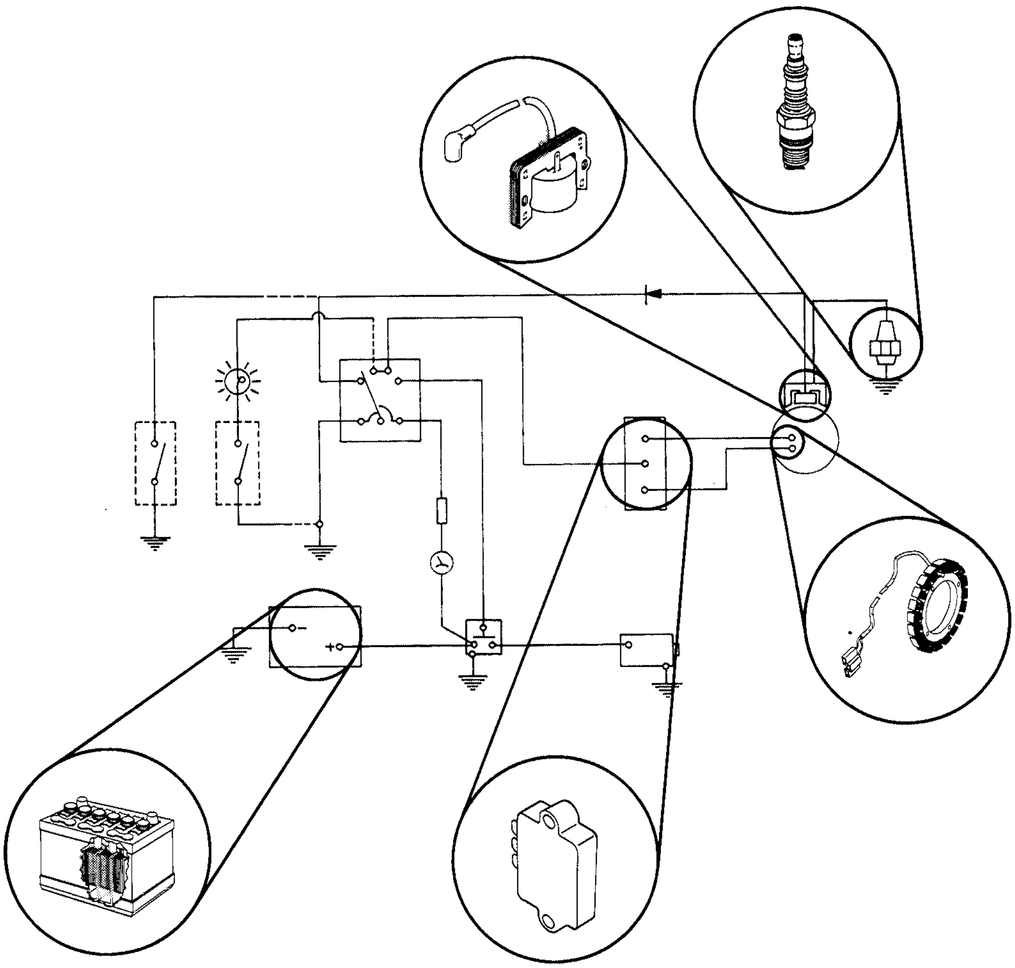
ENGINE ELECTRICAL SYSTEMS



ELECTRICAL SYSTEMS

IGNITION THEORY AND FUNCTION

Power in an internal combustion engine is developed by the expanding gases which result from the burning of an air/fuel mixture in the combustion chamber. With a quality of fuel that meets the engine requirements, the proper air/fuel mixture, and correct timing of the spark to ignite the mixture, that burning process should occur evenly and steadily to give normal, continuous power (or combustion).

It is the function of an engine ignition system to deliver enough voltage to the spark plug at precisely the right instant within each engine cycle to ignite a compressed fuel/air mixture in the combustion chamber—and to repeat the process thousands of times every minute the engine is in operation.

That function may sound quite impressive just by itself. However, if we analyze exactly what is being done by the ignition system, its function becomes awesome indeed.

A typical single cylinder engine, with a spark gap of .025, requires from 5000 to 20,000 volts to bridge the spark gap. In a magneto system, that amount of voltage must be generated entirely within the system from a source that is capable of producing only about 200 volts. And, if the engine is running at 3600 RPM, that 5000-20,000 volts must be generated and delivered to the spark plug 30 times each second. So you see, the job being done by the ignition system is no small task. The next time someone complains that he needs to replace an ignition coil after only 500 hours of running, remind him that the coil has already produced as many as 50 million ignition sparks during its life.

Due to their light weight and simplicity of operation, magneto ignitions are used on most small gasoline engines. Battery ignition systems require, in addition to the battery, a means to recharge it, such as a generator or an alternator, and are generally used on engines of 10 or more horsepower.

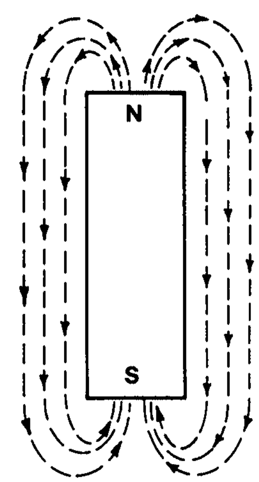
Whether the ignition system is magneto or battery, the purpose is the same: to produce a properly timed surge of high voltage electrical energy, which flows across the spark plug gap to create the spark which will ignite the fuel mixture.

Now that we have gained some appreciation for the job performed by an ignition system, let's look at some of the theories and functions behind the systems.

MAGNETO IGNITION

A magneto can be thought of as a type of generator which converts mechanical energy to electrical energy through the process known as electromagnetic induction. In order to understand magnetic induction, we need to have a basic understanding of magnets and magnetism.

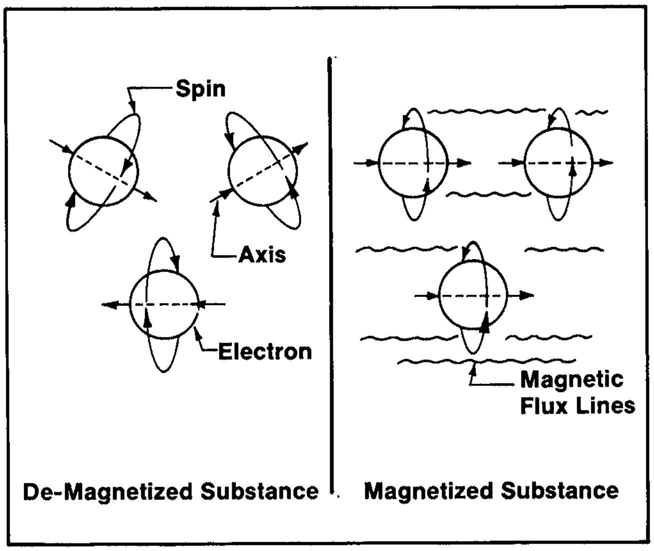
There are two classifications of magnets, natural and artificial. The magnets used in ignition systems are artificial magnets, which means their magnetic properties have been electrically induced or created. The space surrounding a magnet is permeated by magnetic lines of force, called flux, which are concentrated at two points . . . the north and south poles. In theory, the flux lines are directed away at the north pole and re-enter at the south pole. These flux lines form definite patterns which vary in density according to the strength of the particular magnet. The region surrounding a magnet at which its magnetic influence is effective, is referred to as its magnetic field.



Magnetic Flux Lines

All compounds are made up of atoms and electrons. Each of the electrons is spinning on an individual axis, just as the earth rotates on its axis. Normally, these axes are pointed in a helter skelter pattern. However, if we take an artificial magnetic substance and place it within a magnetic field, the axes align themselves and the individual fields combine to form a strong magnetic field around the substance. This phenomenon is known as magnetic induction.

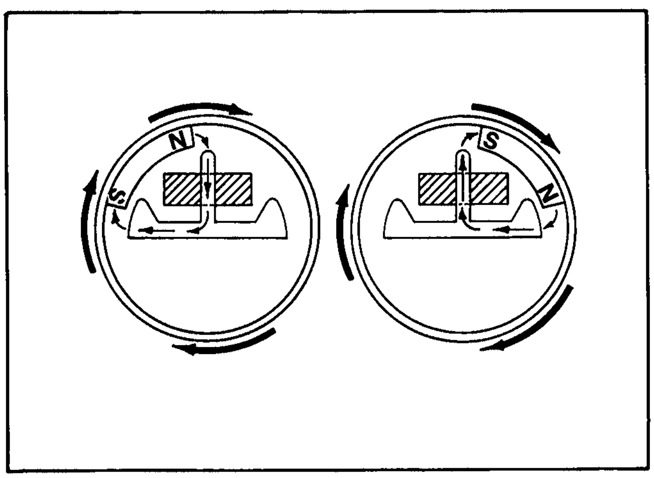
In a substance which is not very dense, such as iron, the axes will return to the helter skelter pattern and the induced magnetism will be quickly lost once the magnetic field is removed. In very dense substances, the axes will remain in alignment and the induced magnetism will be retained indefinitely, even when the magnetic field is removed. Such substances are referred to as "permanent magnets."



Magnetized/De-Magnetized Substance

How does all of this magnetic theory relate to the magneto ignition system?

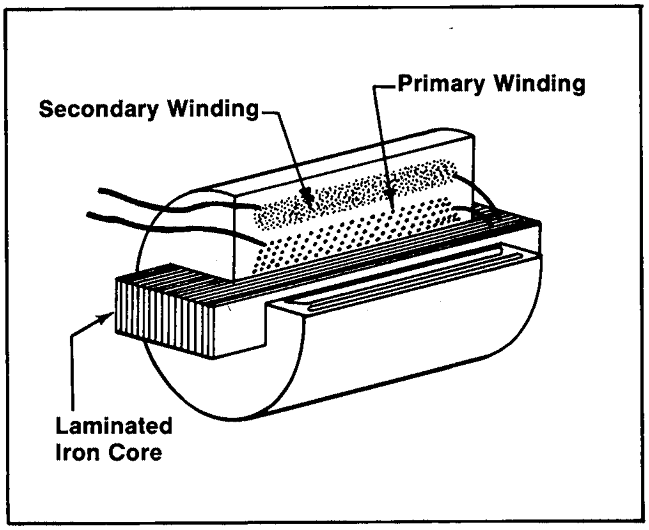
In the magneto system we have one, or more, permanent magnets mounted to the inside rim of the flywheel. We have a laminated iron core mounted to the bearing plate within the magnetic field of the permanent magnets. Iron has low magnetic reluctance, so when the permanent magnet rotates past the iron core, the flux lines will travel through the core, and the core will temporarily take on magnetic properties.



The Magneto Cycle

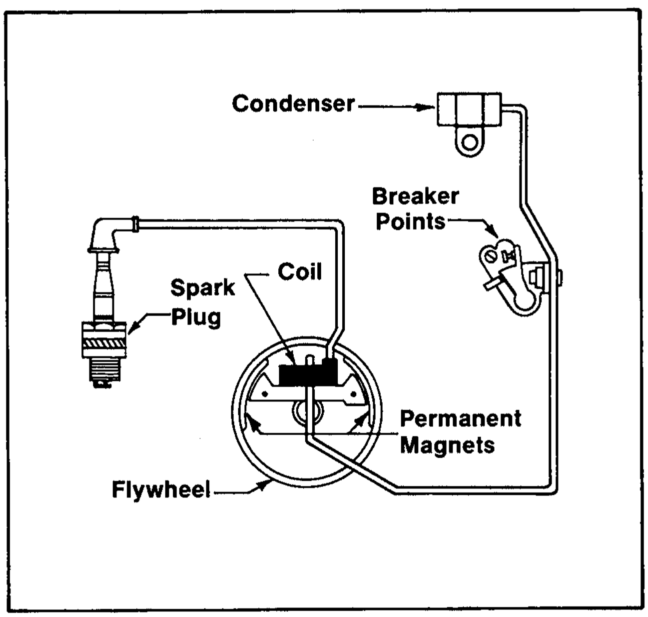
Around the iron core we have an ignition coil which contains two sets of windings, commonly referred to as "primary" and "secondary," wrapped in a circular pattern within the ignition coil. These windings are made of copper which is a good conductor of electrical current.

Whenever magnetic lines of force "cut" across a conductor, an electromotive force (EMF) is induced within the conductor.



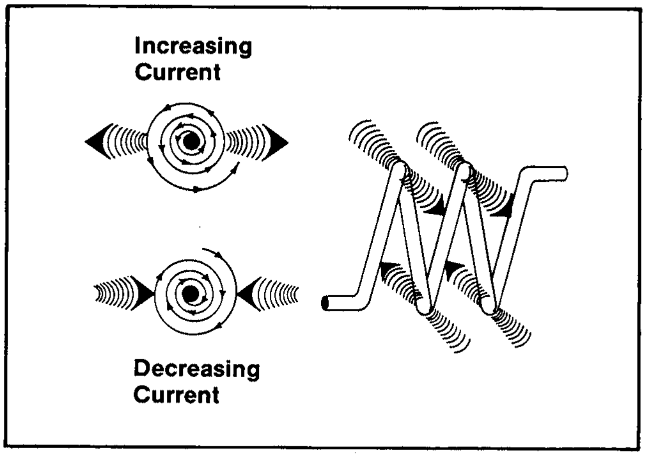
Typical High Tension Coil

If the conductor is part of a completed or "closed" circuit, this EMF will cause current to flow. When the breaker points are closed, the primary windings are part of a completed circuit, and current will flow in those windings.



Typical Flywheel Magneto Ignition System

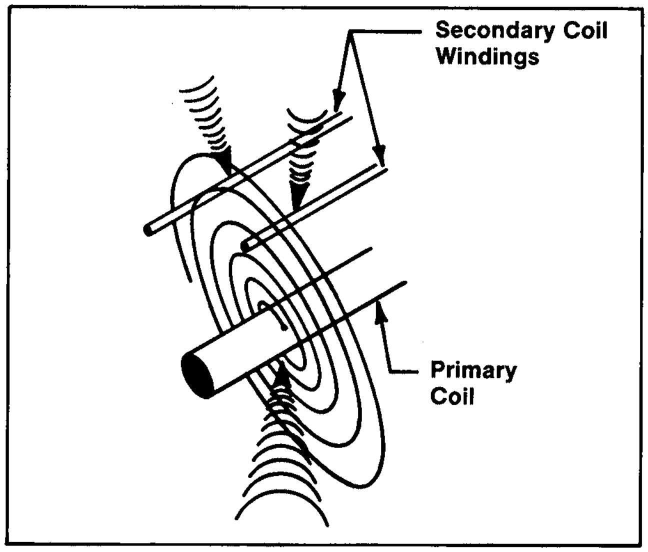
Now another form of inductance, called self-inductance, is utilized to intensify the electrical energy in the primary. Whenever current flows in a conductor, a magnetic field is created around the conductor. If the conductor is wound in a coil, the field created around each loop links magnetically with adjacent loops whenever the current changes in value. An abrupt halt in the flow of current will cause the field from each winding to collapse across the adjacent windings inducing an EMF which creates another surge of current that is many times greater than the original current induced by the magneto.



Self-Inductance

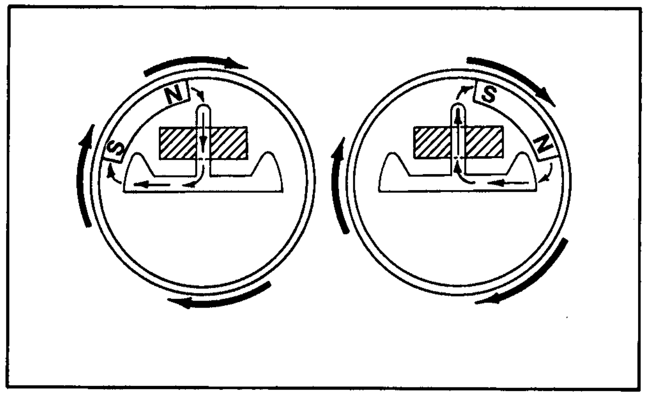
In order to create the high voltage necessary to jump the spark gap, still another form of inductance, is utilized. If we place a second set of windings in close proximity to the primary windings, the self-induced magnetic field surrounding the primary also "cuts" the secondary windings, and an EMF is built up in those windings through mutual inductance.

In a typical ignition coil, there may be as many as 100 secondary windings for each primary winding. If we allow the current in the primary windings to reach a maximum value and then break the circuit, the self-induced field around each winding will collapse and cut all of the corresponding secondary windings. Since there are 100 times as many windings in the secondary, the voltage imposed in the secondary can be up to 100 times greater than the voltage in the primary. For example, if the voltage in the primary reaches 200 volts, the voltage in the secondary could go as high as 20,000 volts.



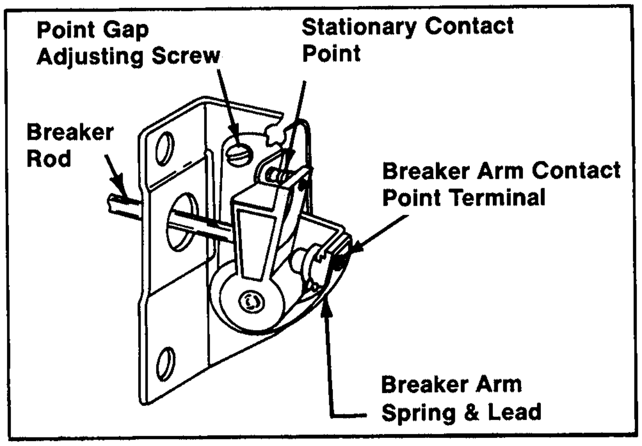
Mutual-Inductance

Current in the primary windings will reach its maximum value at the instant that the magnetic flux changes direction within the stator core. This is the point at which ignition should take place, so we get optimum output from our ignition system and the hottest possible spark.



The Magneto Cycle

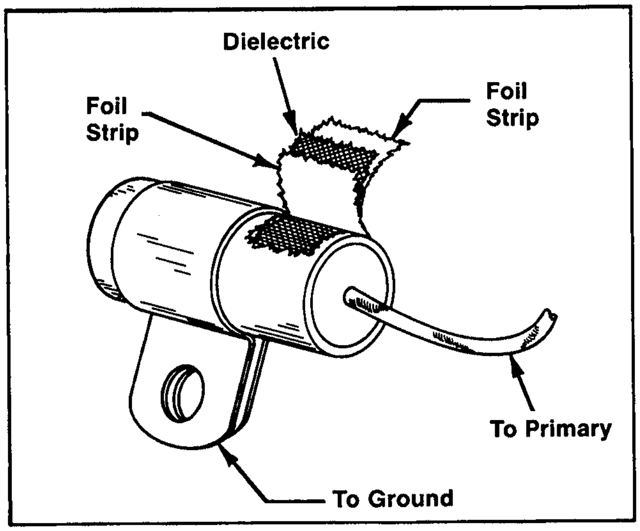
This is accomplished through the mechanism of the breaker points. The points are part of our primary circuit. As long as the contacts are closed, current will flow in the primary circuit. At the instant that current reaches the desired maximum value, the ignition lobe on the camshaft will push against the breaker rod to open the contacts. Current in the primary will stop, the self-induced magnetic field around the primary windings will collapse, and the high voltage generated in the secondary windings will fire across the gap on the spark plug.



Typical Ignition Breaker Points

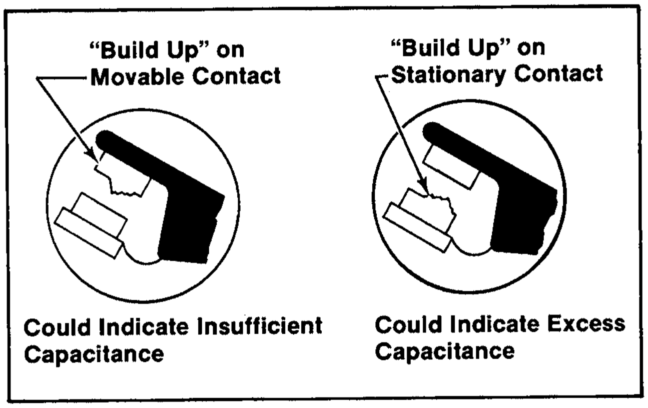
The collapse of the magnetic field around the primary windings not only generates high voltage in the secondary, it also causes an increased EMF in the primary. This increased EMF will have a tendency to arc across the breaker contacts and burn the contact surfaces. To prevent that problem, a condenser is mounted in the primary circuit somewhere between the coil and the points.

The condenser contains two foil strips separated by a dielectric insulator. One foil strip is connected to the condenser terminal or lead wire, and the other strip is connected to the case of the condenser. The strip connected to the "hot" side absorbs just enough current to prevent arcing as the contacts are separating.



Typical Condenser

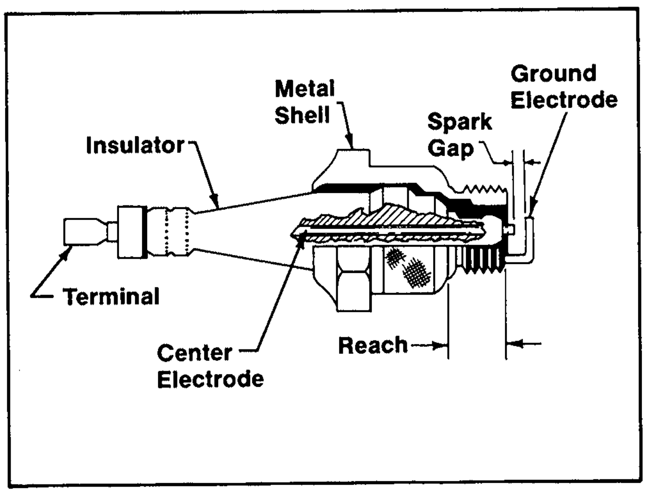
The capacity of the condenser to absorb and store electrons (capacitance) must be matched to the output of the coil. A condenser with too much capacitance will cause a weaker spark, while one with insufficient capacitance will obviously not prevent the arc. Metal transfer on the breaker points will be an indicator of incorrect capacitance. The problems which can result from incorrect capacitance make it very important that you always use the condenser which is specified for any given engine.



Effect of Condenser Condition On Breaker Points

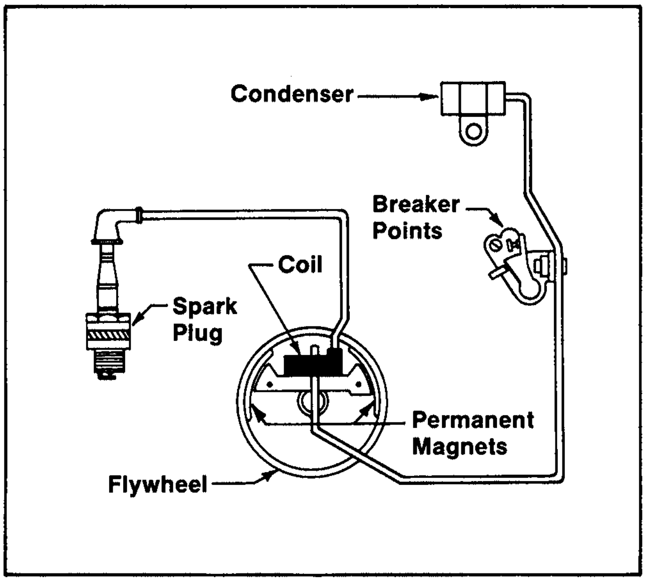
The last remaining component in our ignition system is the spark plug. Without it, the rest of our ignition system would be useless.

A typical spark plug consists of a metal shell, a ceramic insulator, a center electrode connected to the end terminal, and a side electrode connected to the shell. The electrodes are separated by an air gap of .025. Producing an electric arc across the air gap is the end purpose of the entire ignition system.



Typical Spark Plug

The center electrode, through the end terminal, is connected to the secondary windings in the coil by a high tension lead wire. If the EMF generated in the secondary has sufficient strength, current will flow through the high tension lead, through the center electrode, and bridge the air gap to make a completed circuit to ground.



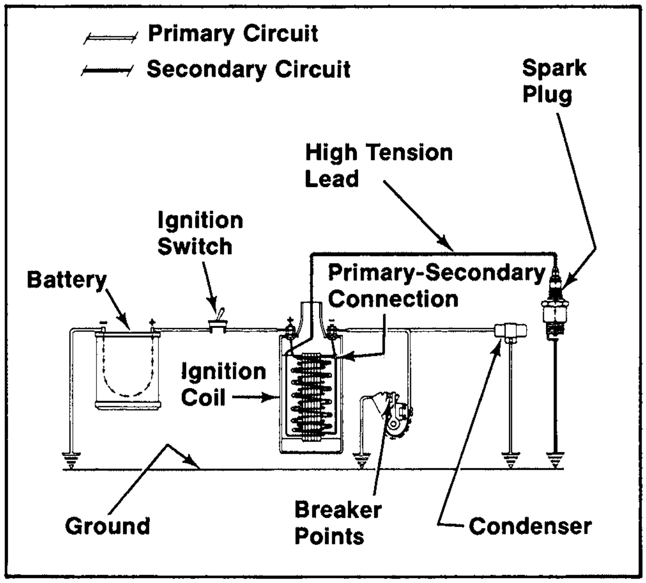
Typical Flywheel Magneto Ignition System

Several different magneto systems have been used on Kohler engines over the years, but the principles of operation we have discussed will apply to all of them. The flywheel magneto system used in current production is one of the simplest designs ever developed. It does, however, offer one distinct advantage over most other magneto systems in general use. The breaker points and condenser are mounted on the outside of the engine, so timing adjustments and minor tune-ups can be performed without removing the flywheel.

BATTERY IGNITION

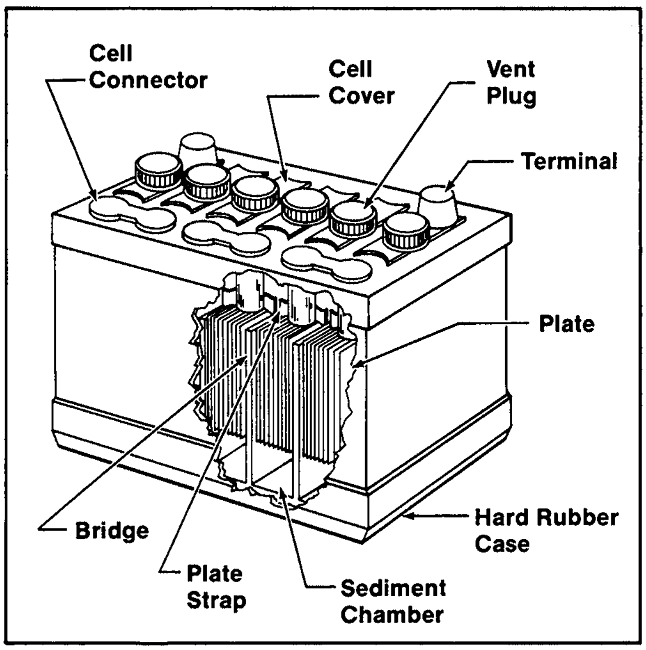
At one time, all Kohler engines had magneto ignition. More recently, however, the battery ignition system has had more widespread use, especially on engines of ten or more horsepower.

The battery ignition system functions much the same as the magneto system, except that the primary current is drawn from a storage battery. Because of the comparatively high level of current available from a good storage battery, this system will normally provide a stronger spark than the typical magneto system.



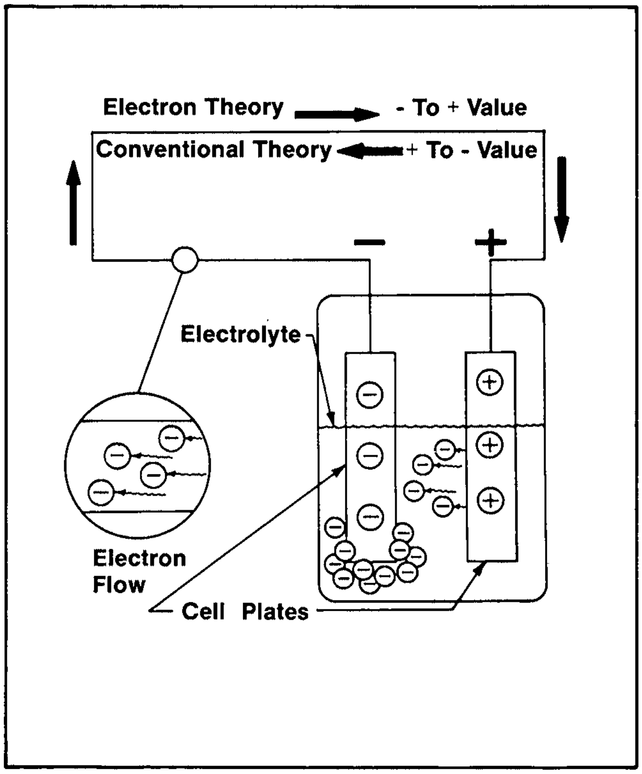
Primary (Low Voltage) and Secondary (High Voltage) Circuits

The battery that is commonly used is a lead-acid storage battery, so named because lead is used to make the cell plates and sulfuric acid is used as the electrolyte. It should be a 12 volt battery with a rating of 32 amp. hour or higher. A typical 12 volt battery has a hard rubber or plastic case with six individual compartments or cells. Each cell contains a specific number of sets of negative and positive plates. The plates are all made of lead, but the positive plates have a coating of lead oxide, while the negative plates have a porous or spongy surface.



Construction Details-Typical Battery

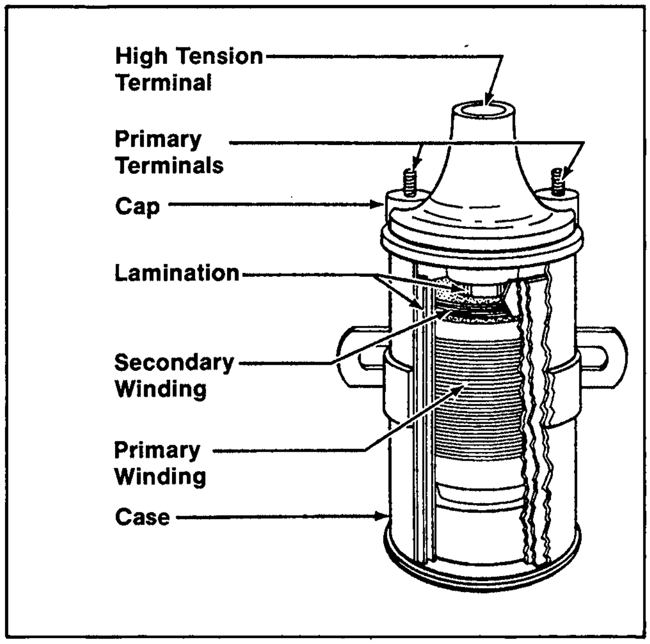
When the battery is "charged" with electrolyte, a chemical reaction takes place between the lead plates and the electrolyte. The chemical reaction results in a migration of electrons from one set of plates to the other. Since electrons have a negative charge, one set of plates takes on a negative charge, and the other set takes on a positive charge. All plates of like charge are interconnected and connected to their respective terminals of the battery, so the cumulative totals of the charges are present at the terminals. If the battery is fully charged, there is a difference in electrical potential of about 12 volts between the terminals. If the terminals are connected, electric current will flow through the circuit. By hooking our ignition coil into the circuit, we can use current from the battery to energize the primary windings in our coil.



Difference In Electrical Potential Produced In Simple Battery

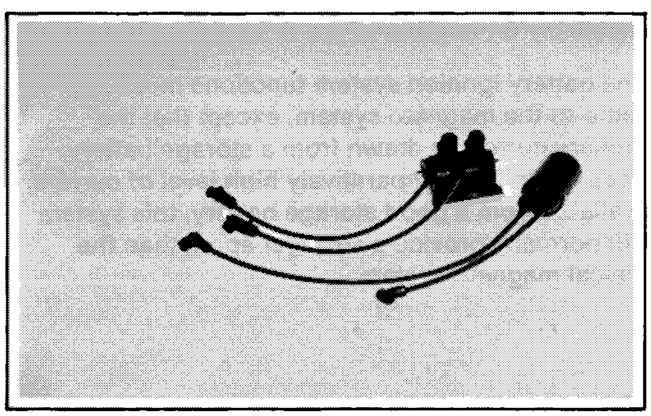
The coil used for battery ignition is very similar in construction and function to the magneto coil already discussed. The major difference is that the secondary windings are located between the primary windings and the core. Also, the battery coil has laminations outside the primary windings. This provides maximum concentration of the magnetic fields to achieve optimum coil output.

IMPORTANT: *It should be pointed out here that although the battery ignition coil for single cylinder Kohler engines looks like a standard automotive coil, the number of windings and internal components often vary. Use of an automotive coil on a Kohler engine will often result in poor or erratic ignition.*



Construction Details-Typical Ignition Coil

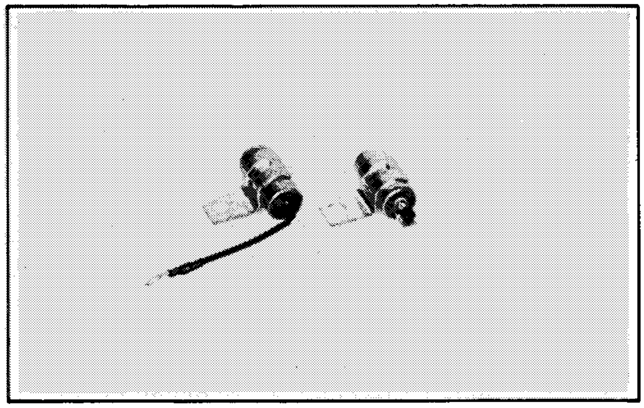
The battery ignition coils for twin cylinder Kohler engines are very similar to the single cylinder coil, with one exception. In the single cylinder coil, one end of the secondary windings is connected to the high tension lead and the other end is connected to the primary windings at the negative terminal. In the twin cylinder coils, both ends of the secondary are connected to a high tension lead and there is no link between primary and secondary. The secondary functions as an independent loop circuit to fire both spark plugs simultaneously.



Battery Ignition Coils

The condensers used for battery ignition systems have the same function as those used with the magneto system. However, the capacitance will normally be higher because of higher primary voltage.

Kohler battery ignition condensers can be distinguished by their "pigtail" lead wire, as opposed to the end terminal found on the magneto condensers. The lead wire must always be attached to the negative terminal of the coil.

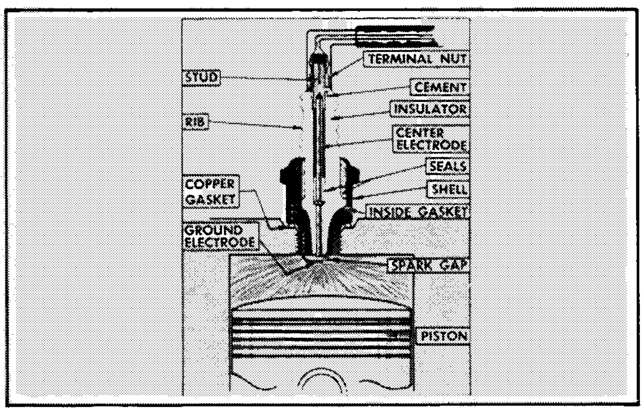


Condensers

IGNITION TIMING

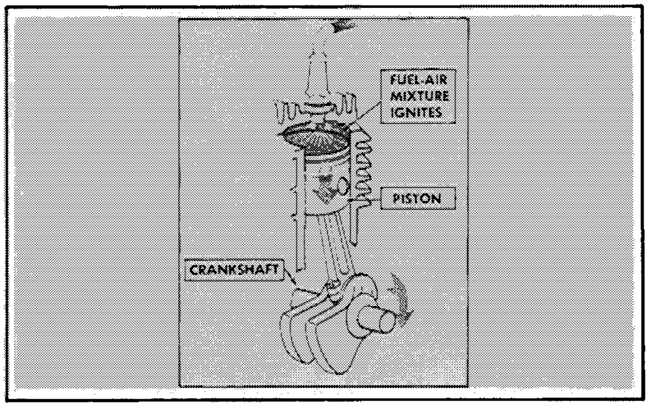
Exact timing of the ignition spark is essential to efficient operation of an engine. The spark must occur at exactly the right moment in respect to the position of the piston in the cylinder.

When the spark plug ignites the fuel charge in the combustion chamber, the flame pattern moves outward from the spark plug electrode into the combustion chamber. A constant amount of time is always needed for complete combustion and during this interval of time, the pressures of the burning gases start low, build up to a maximum value at about midpoint in the burning process, and then taper off again.



Igniting The Fuel In Combustion Chamber

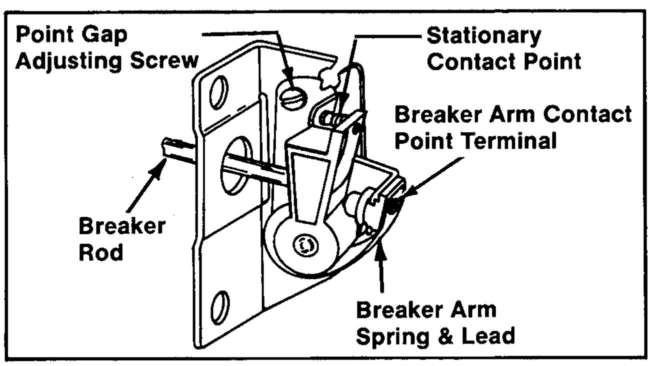
It is desirable that the highest combustion pressures are reached when the piston is still near the top of the power stroke. Therefore, the combustion process must actually be started before TDC in order to most effectively use the peak force of the combustion pressures. If we waited until TDC before starting the combustion process, the piston would be well on its way downward in the power stroke, and the full force of combustion would be exerted too late to realize greatest power. On most Kohler engines, best overall performance is obtained if the spark occurs about 20° of crankshaft rotation BTDC.



The Power Stroke

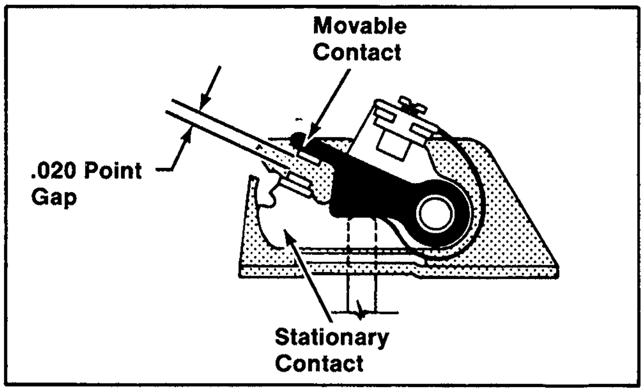
The basic timing of the spark in relation to engine position is established through proper positioning of the ignition cam in respect to degrees of crankshaft rotation. However, it is possible to alter the timing within certain limits, by altering the point at which the breaker points open.

The breaker point assembly is designed with one stationary contact and one movable contact which is part of an adjustable plate. By shifting this plate, the instant of point opening is changed in respect to movement of the ignition cam, thus causing the spark to occur earlier or later in the engine cycle, depending on which way the plate is shifted. Opening the gap advances the timing and closing the gap retards the timing.



Typical Ignition Breaker Points

The initial timing setting is made by adjusting the breaker point gap to .020, as checked with a feeler gauge. Assuming that all other conditions are right, this setting should allow you to get the engine started.

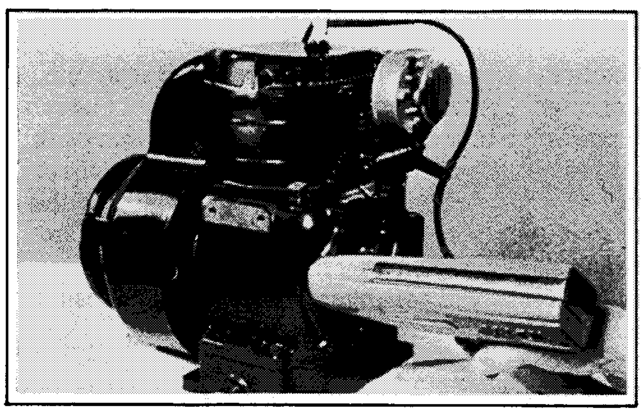


Breaker Point Gap

The final timing adjustment is best performed with the use of an automotive timing light while the engine is operating. All Kohler engines are equipped with a timing sight hole and timing marks on the flywheel.

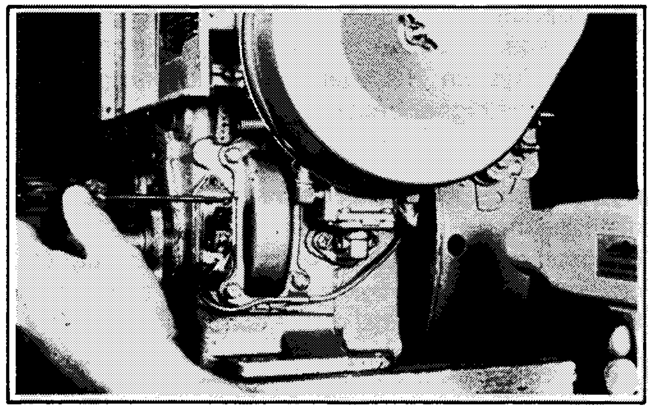
Connect the timing light per the manufacturer's instructions. Start the engine running and shine the timing light into the sight hole.

On magneto ignition engines the sight hole will be in the bearing plate on the side opposite the carburetor.



Setting Timing - Magneto Ignition Engines

On battery ignition engines it will be in the blower housing on the carburetor side.



Setting Timing - Battery Ignition Engines

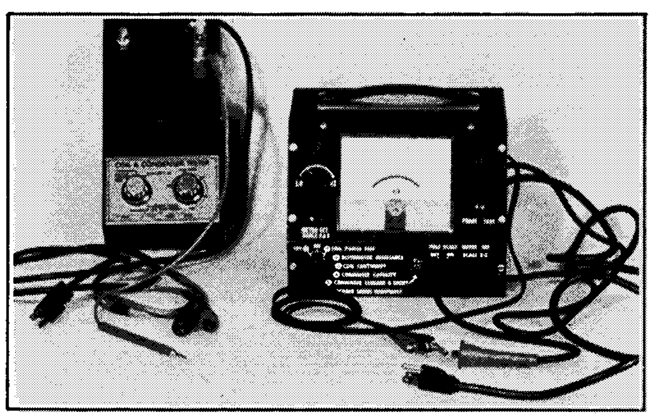
Adjust the breaker points as necessary to bring the spark mark (S) into the center of the sight hole.

For twin cylinder engines, refer to the appropriate service manual for sight hole location and timing procedure.

IGNITION COMPONENT TESTING

Troubleshooting an ignition problem can be an exasperating task, especially if you try to use hit-and-miss or component replacement techniques. A commercial ignition component tester is a "must" in the modern day small engine shop to avoid wasting mechanics time and customers' money.

The two common brand names for small engine ignition component testers are Merc-O-Tronic and Graham-Lee. Both of these manufacturers make large multi-scale, table-top models and also less expensive, more portable models. If one of the large models is within your means, it will do an excellent job of testing nearly every phase of component operation. However, the small, less expensive models are more than adequate to determine if a component is good or bad.



Ignition Component Testers

There are many different tests which can be made on ignition components, but there are four basic tests which can normally help you determine if your ignition components are good or bad. Since these four tests can all be performed with one of the less expensive commercial testers, or a good quality ohmmeter, we will concentrate our efforts on them. The four tests are:

I. Coil Power Test.

II. Surface Insulation Test.

III. Condenser Leakage and Short Test.

IV. Breaker Point Contact Resistance.

The tester we will use is the Merc-O-Tronic model 98. If you have a different make or model, follow the manufacturer's instructions for performing the same four tests.

I. Coil Power Test

1. Connect the tester to the coil as follows:

   A. Connect small red tester lead to positive (+) terminal or primary lead wire of coil.

   B. Connect small black tester lead to negative (—) terminal or coil ground wire.

   C. Connect large red tester lead to spark plug lead terminal.

   D. If testing coil with components mounted on engine, place a piece of cardboard between the points.

   E. For twin cylinder coils, connect a jumper lead between the negative (—) terminal and the second spark plug lead terminal.

2. Make sure current control knob (A) is turned to the extreme left.

3. Turn selector switch to position No. 1 (Coil Power Test).

4. Slowly turn current control knob clockwise and watch the current value on Scale No. 1.

5. If a steady spark is observed at the spark gap, with a current value of 1.5 or less, the coil is good. NOTE: Coil 277375 used on K482, K532, and K582 engines has relatively high resistance Coil power test should be made on tester which uses 115 volts power source. Merc-O-tronic Testers (Model 98,9800) with 7-1/2 volt battery power source often give erroneous results.

6. If spark is faint, intermittent, or current value exceeds 1.5, coil should be replaced.

7. Return current control knob to extreme left and turn selector knob to "OFF."

   NOTE: Magneto coils must be mounted on stator laminations for Coil Power Test and Surface Insulation Test.

Coil Power Test

II. Surface Insulation Test

1. Leave coil connected as for Coil Power Test, but disconnect large red lead from spark plug lead.

2. Plug insulation test probe into jack on front of tester.

3. Turn current control knob to "HI" or until meter reaches full scale.

4. Move test probe quickly over insulated surfaces of coil and spark plug lead(s).

   IMPORTANT: *Do not hold probe at one point too long. Complete test as quickly as possible.*

5. Return current control knob to extreme left and selector knob to "OFF."

   NOTE: A faint spark occurring around the coil during probing is a corona spark and does not indicate a defective coil. A strong spark at any point indicates a leak and coil or lead should be replaced.

Surface Insulation Test

III. Condenser Leakage & Short Test

1. Plug tester into 115 V. wall outlet.
2. Connect small red tester lead to condenser terminal or end of condenser lead.
3. Connect small black tester lead to condenser case or mounting bracket.
4. If condenser is mounted to engine, condenser lead must be disconnected.
5. Turn selector switch to No. 5, "Leakage and Short."
6. Depress red button on front of tester and hold for at least 15 seconds.
7. Meter pointer should move to the right initially, but return to the narrow black bar at left end of scale 5. Any readings to the right of black bar indicate condenser is defective.

Condenser Test

IV. Breaker Point Contact Resistance Test

NOTE: Breaker point resistance can be tested with either of the large commercial testers, or with an ohmmeter capable of reading fractions of a ohm. Procedures for both types of testers are provided.

1. Turn selector switch to No. 2, "Distributor Resistance."
2. Clip small red and black tester leads together.
3. Turn meter adjustment knob for scale No. 2 until meter pointer lines up with "set" position on left end of scale No. 2.
4. Unclip tester leads.
5. Clip one tester lead to stationary contact side of points; clip other lead to moveable contact side.
6. Make sure terminal attaching screw is turned all the way in so normal tension is applied to contacts.
7. Make sure contacts are closed and observe pointer on scale No. 2.
8. Pointer should be within "OK" block at left of scale.
9. If resistance is above "OK" block, clean points with electrical contact cleaner and/or stiff paper (business card). Repeat resistance test.
10. If resistance cannot be brought within "OK block, replace points.

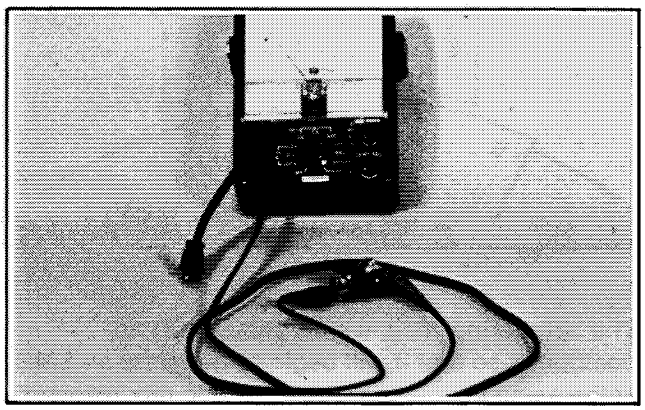
Breaker Point Resistance Test

Breaker Point Resistance—Ohmmeter Test

NOTE: Ohmmeter used for this test must be capable of reading resistance values of .1 ohms.

1. Set ohmmeter to most sensitive scale.
2. Clip ohmmeter leads together and set meter.

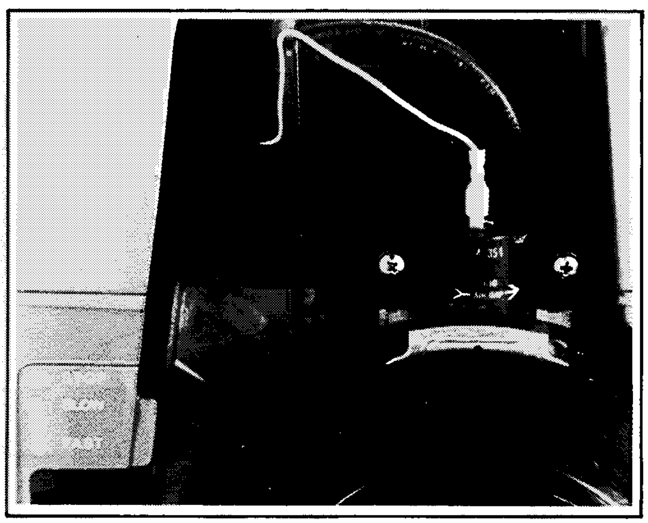
3. Clip one ohmmeter lead to moveable contact side of points; clip other lead to stationary contact side.
4. Make sure terminal attaching screw is turned all the way in so normal tension is applied to contacts.
5. Read resistance across contacts.
6. Resistance should be .2 ohms, or less.
7. If resistance is above .2 ohms, clean contacts with electrical contact cleaner and/or stiff paper (business card). Recheck resistance.
8. If resistance cannot be brought below .2 ohms, replace points.



Breaker Point Resistance Test - Ohmmeter Test

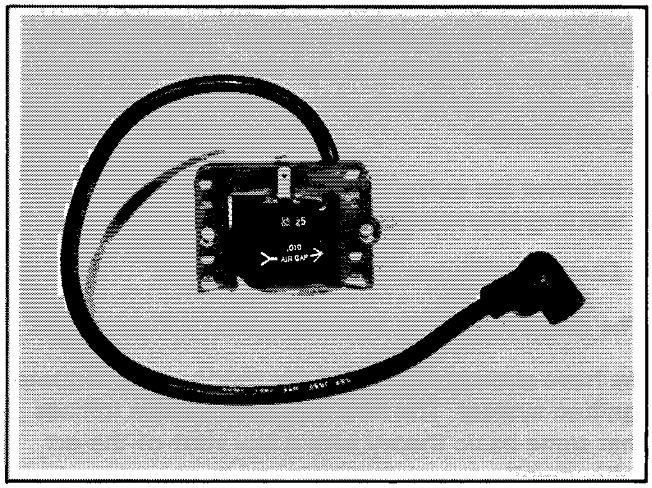
MAGNUM SOLID STATE IGNITION SYSTEM

The new Magnum engines feature an entirely new solid state inductive magneto ignition system. All engines, both electric and recoil start, will utilize the same system.



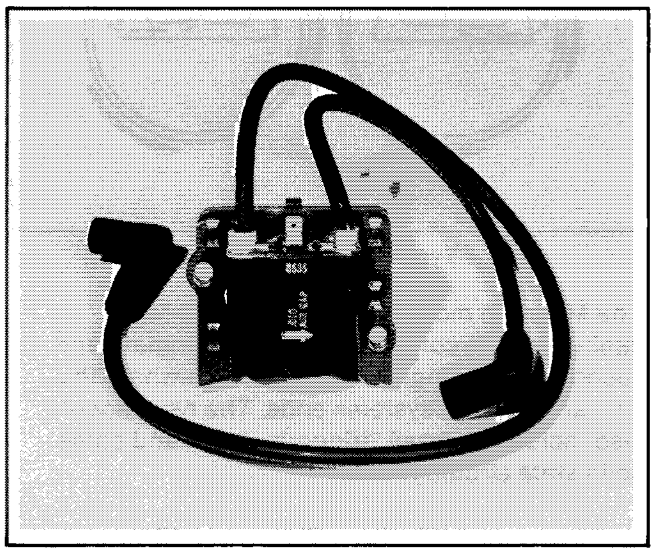
Solid State Ignition Test

The ignition modules for the M8 and M10-M16 are identical except for the larger lamination radius on the 10-16 HP module.



Magnum Solid State Ignition Module - Single Cylinder Engines

The twin cylinder module uses the same basic circuitry but has more windings to produce the energy necessary to fire two cylinders.



Magnum Solid State Ignition Module - Twin Cylinder Engines

The performance of the new solid state ignition system has exceeded even Kohler's strict specifications. The system was tested in the laboratory for high temperature performance and endurance, salt spray and high humidity, and vibration resistance. There were **no** failures in more than 17,000 hours of endurance testing. To test the system under field conditions, 50 Magnum engines were put into service at an amusement park. The engines accumulated over 200,000 hours with only two failures, both of which were due to manufacturing defects, since corrected by the vendor.

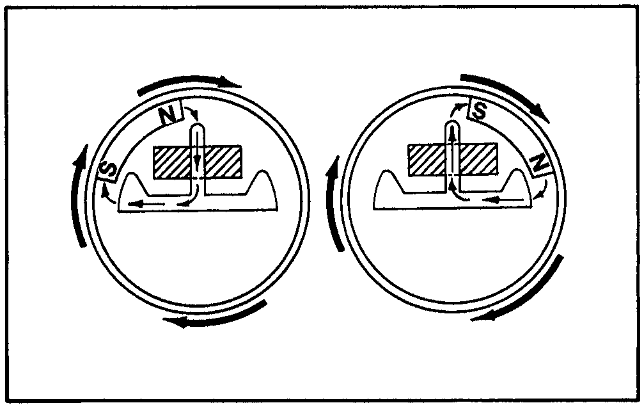
Theory of Operation

The basic magneto ignition system has been around for many years; and for good reason, it's difficult to improve on its simplicity and durability. However, in developing an ignition system for the new Magnum engines, it was decided there were two major areas where improvement could be accomplished.

- Improve the output at low RPM's for better starting characteristics.
- Eliminate the need for maintenance.

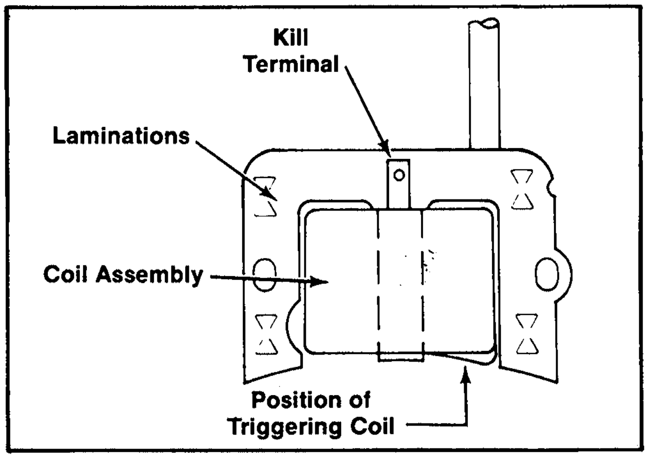
The new system has achieved both of those goals.

We have already discussed the theory of a magneto ignition system. The new Magnum system utilizes that same basic theory with a few start-of-the-art refinements.



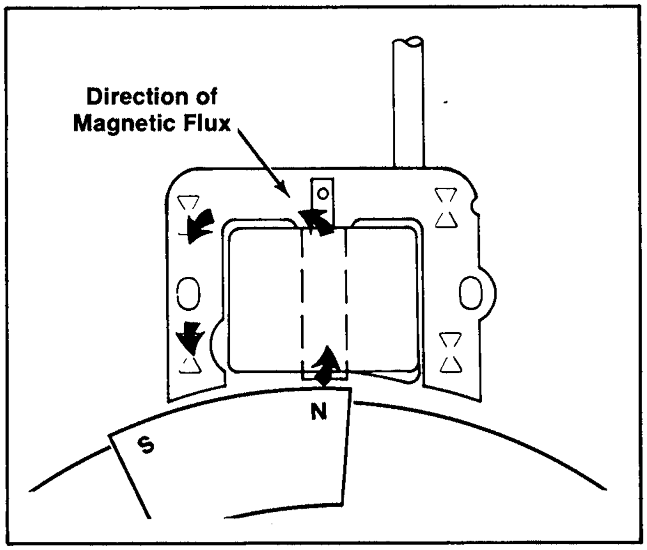
Typical Magneto Cycle

The Magnum module includes a three-leg laminated iron core, and a coil with primary and secondary windings. However, this is where the similarity to past systems ends. The new module also includes a small "triggering" coil and some solid state circuitry.



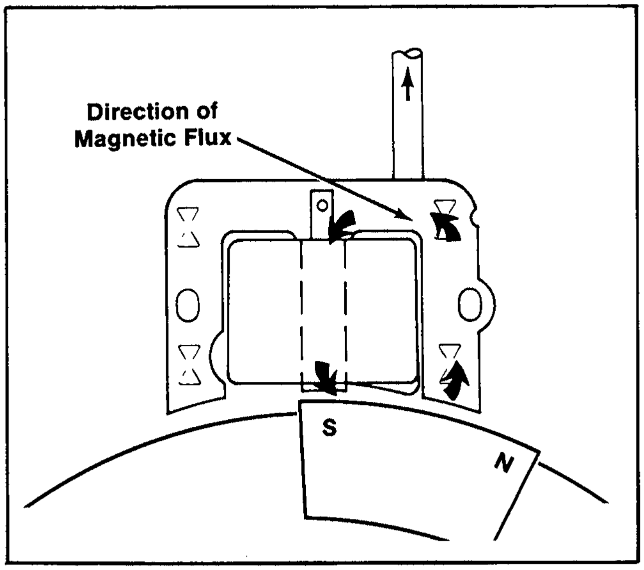
Magnum Solid State Ignition Module

The flywheel magnet rotating past the laminated core causes magnetic flux to flow through the left and center legs of the core. This induces an electromotive force in the primary and secondary windings. The EMF in the primary causes a transistor to switch on, which completes a circuit to ground and current flows in the primary windings.



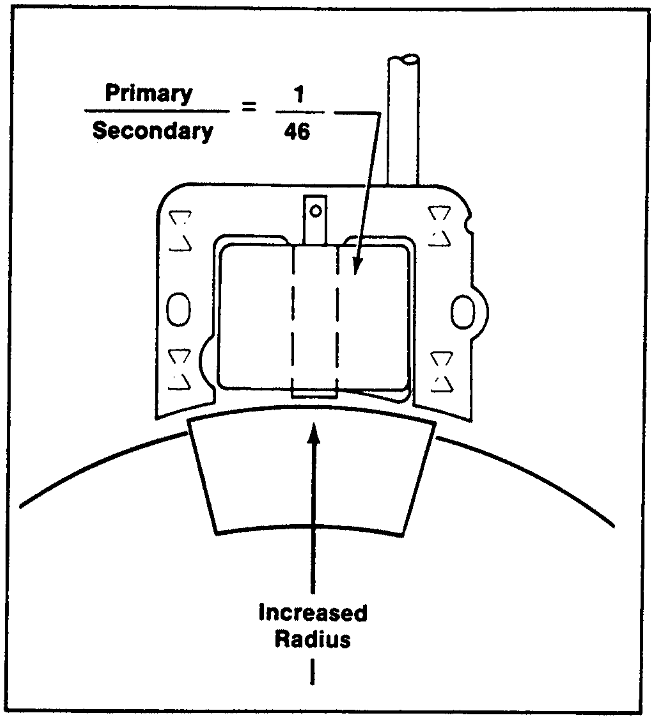
Current Flowing In Primary

The "triggering" coil, within the module, is positioned so that it will begin to generate an EMF at the same instant that the magnetic flux reverses direction in the laminations. The EMF from the "triggering" coil causes the transistor in the primary circuit to switch off instantaneously, and the collapsing field of the primary induces the high EMF in the secondary which bridges the spark gap and provides ignition.



Collapse Of Primary, Spark From Secondary

The Magnum module is positioned outside the flywheel. The additional radius, in combination with a 1 to 46 primary/secondary ratio, provides high output at low RPM's. The spark energy at cranking speed surpasses previous Kohler magneto systems, as well as competitive systems, both past and present.

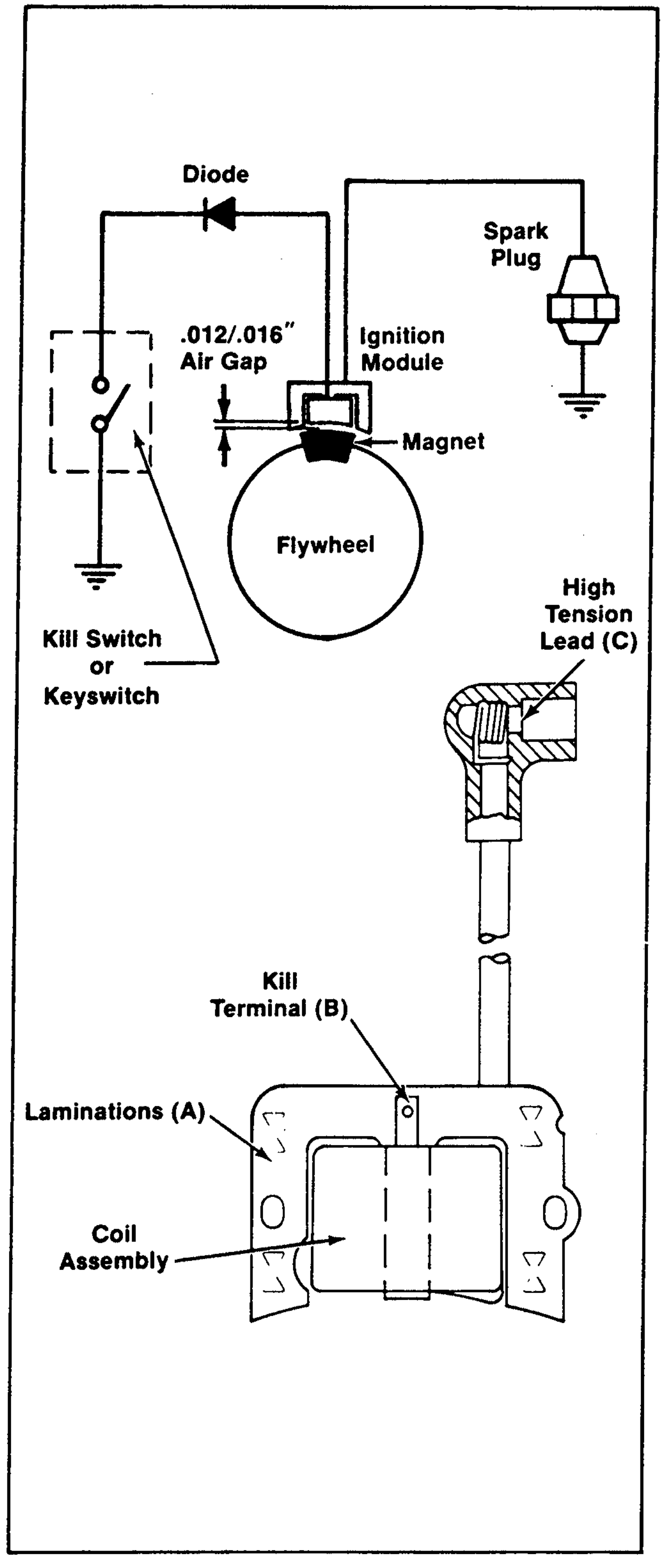


Increased Radius, And Turns Ratio For Increased Output And Performance

Troubleshooting - Single Cylinder

The Magnum single cylinder ignition system consists of the following components.

- A magnet assembly, which is PERMANENTLY affixed to the flywheel.
- A solid state ignition module, which is mounted to the engine bearing plate.
- A kill switch or keyswitch which stops the engine by grounding the ignition module.



Solid State Ignition System - Single Cylinder Engines

Troubleshooting Guide (Single Cylinder)

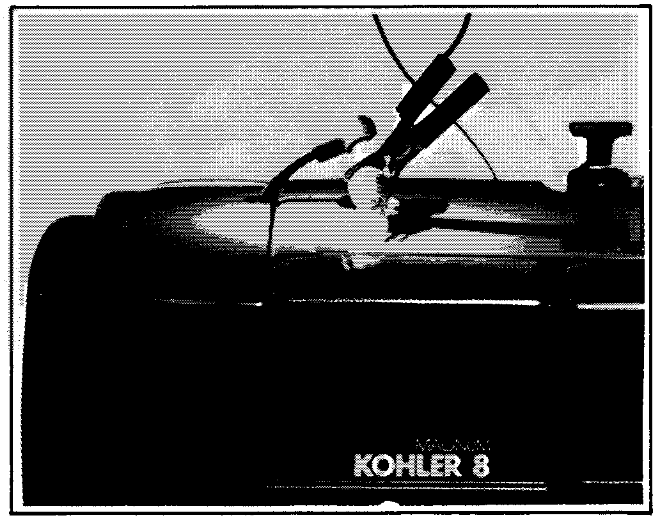
The following guide will help locate and correct ignition problems.

PROBLEM	TEST	CONCLUSION
ENGINE WILL NOT START	1. Make sure spark plug lead is connected to spark plug.	
	2. Check condition of spark plug. Make sure gap is set to .025.	If plug is in good condition, check/adjust gap and reinstall.
	3. Check ignition module using test plug (refer to Ignition System Tester). a. Remove the high-tension lead from the engine spark plug, and connect it to the test plug. NOTE: To maintain engine speeds normally obtained during cranking, do not remove the engine spark plug. b. Connect the large spring clip around the hex portion of the test plug. Connect the alligator clip to a good ground on the engine. c. Make sure the engine throttle control (kill switch) and/or keyswitch are in the "run" position. d. Crank the engine and observe the test plug. A visible and audible spark should be produced.	If a visible and audible spark IS produced, the ignition module is OK. If a visible and audible spark IS NOT produced: a. Make sure engine throttle control (kill switch) and/or keyswitch are in the "run" position. b. Check wires and terminals of ignition module and other components for accidental grounding and/or damaged insulation. c. If wires and terminals are OK, the ignition module is probably faulty and should be replaced. Test module further using an ohmmeter (Test 4).
	NOTE: Use a low-voltage ohmmeter when ohmmeter is required. Always zero ohmmeter on each scale before testing to ensure accurate readings.	
	4a. Measure the primary resistance of module using an ohmmeter. NOTE: Connect negative (-) lead of ohmmeter to kill terminal B. **Primary Leads/Terminals**: A - B — **Primary Resistance**: 1.0/1.3 ohms	If resistance is 0 ohms, module primary is shorted. Replace module. If resistance is infinity ohms, module primary is open. Check keyswitch/wiring for shorts or connections which could apply 12V to kill terminal B. Correct those conditions, then replace module. If resistance is within range, module primary is OK. Test secondary (Test 4b).
	4b. Measure the secondary resistance of module using an ohmmeter. **Secondary Leads/Terminals**: A - C — **Secondary Resistance**: 7,900/10,850 ohms	If resistance is within range, module secondary is OK. If resistance is low or 0 ohms, module secondary is shorted. Replace module. If resistance is high or infinity ohms, module secondary is open. Replace module.

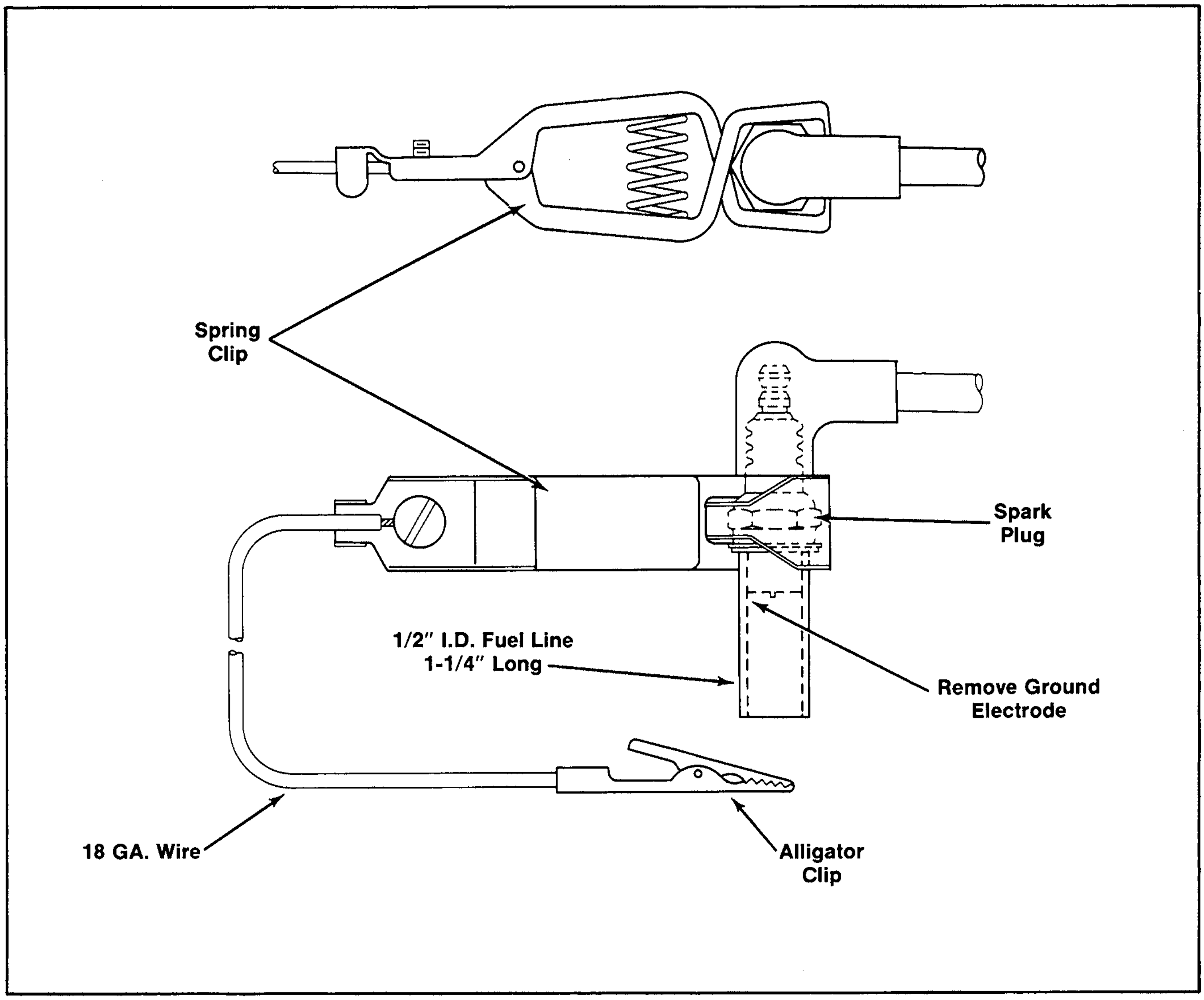
Ignition System Tester

A simple tester can be made to determine if the ignition module is functioning properly.

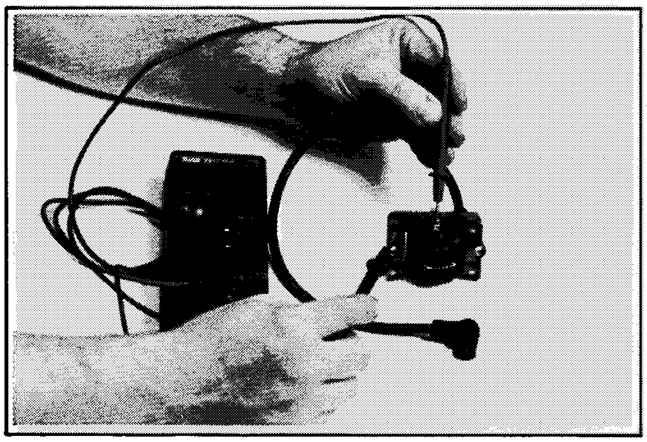
1. Obtain a new RJ-8 or RCJ-8 spark plug.
2. Remove the ground electrode from the test plug. This gives a spark gap of .13". This large gap simulates the spark required under actual engine conditions.
3. Make a lead assembly using a large spring clip, an alligator clip, and 18 gauge wire as shown.
4. Cut off a 1-1/4" length of 1/2" I.D. fuel line and slide it onto the threads of the test plug. It will help to shade the firing tip to make the spark more visible.



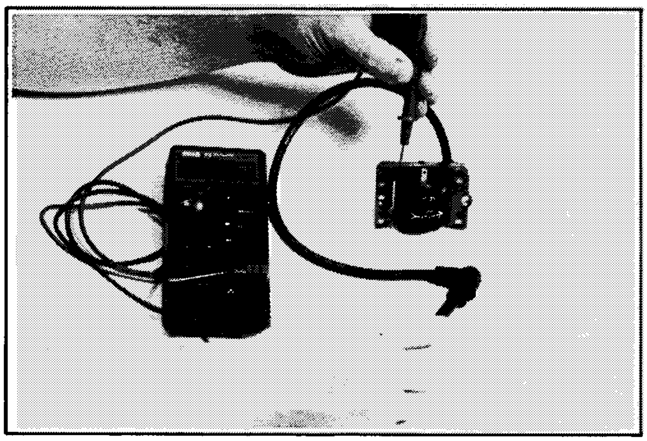
Ignition System Tester



Ignition System Tester - Single Cylinder Engines



Testing Module Primary - Single Cylinder Engines

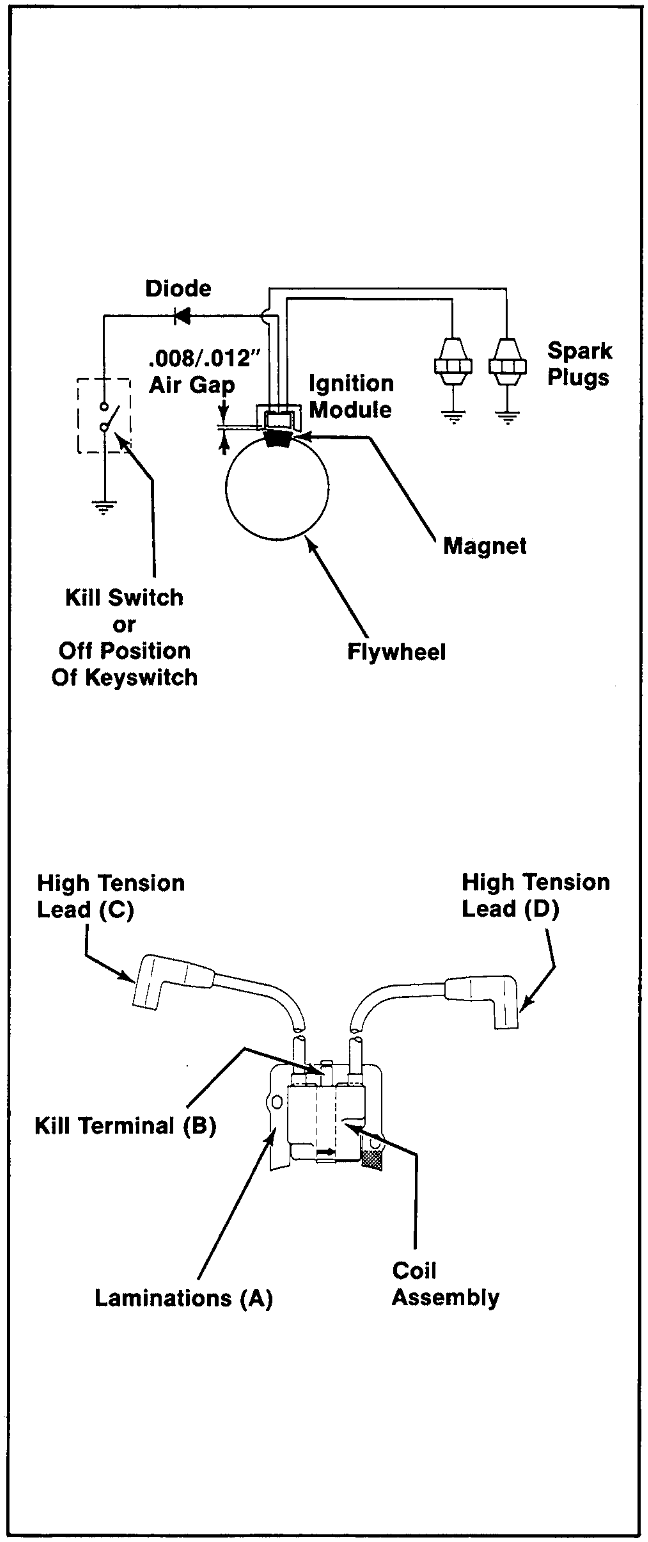


Testing Module Secondary - Single Cylinder Engines

Troubleshooting—Twin Cylinder

The Magnum twin cylinder ignition system consists of the following components.

- A magnet assembly, which is PERMANENTLY affixed to the flywheel.
- An electronic magneto ignition module, which is mounted to the #1 side cylinder barrel.
- A kill switch (or keyswitch) which stops the engine by grounding the ignition module.



Solid State Ignition System - Twin Cylinder Engines

Troubleshooting Guide (Twin Cylinder)

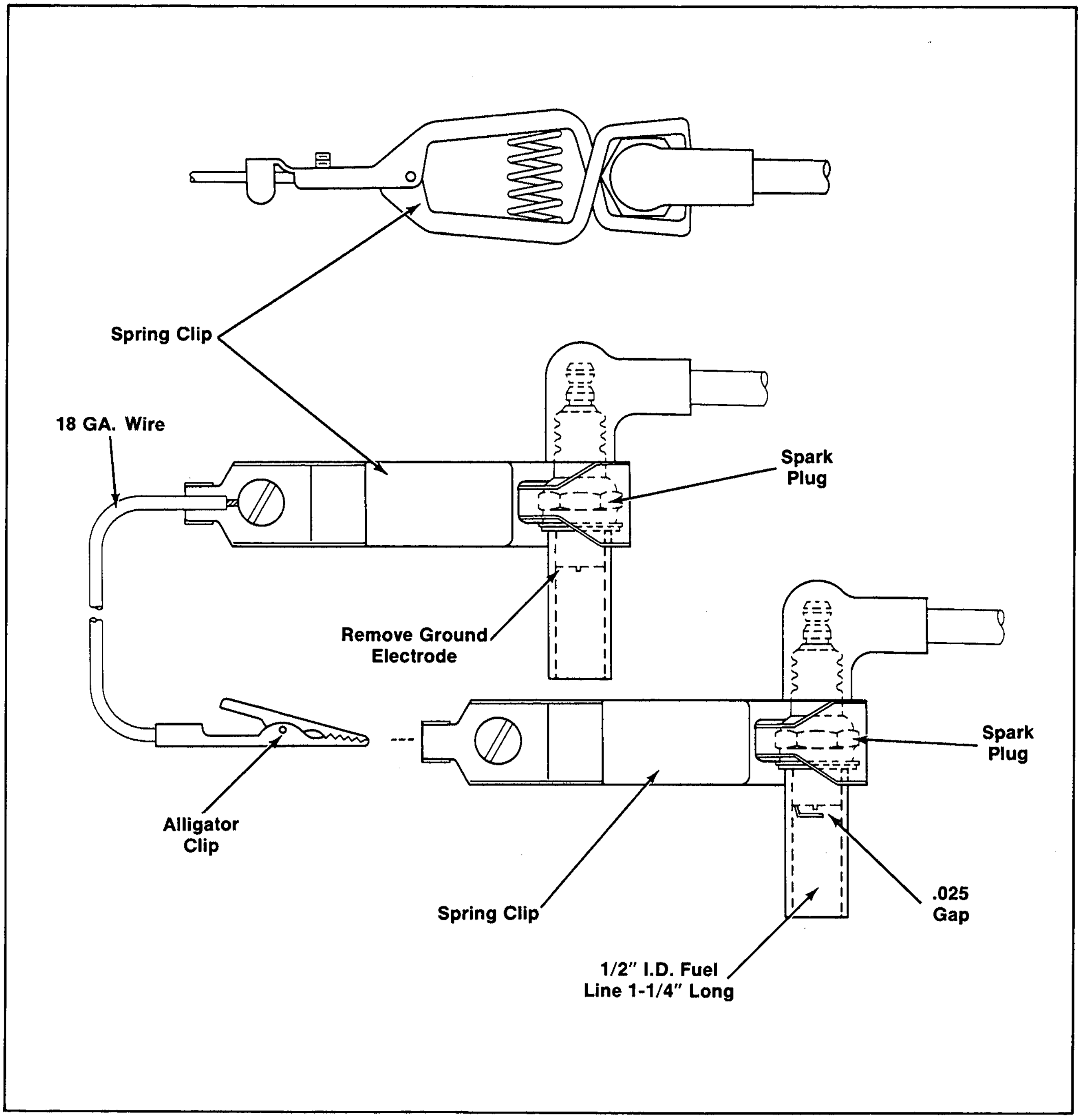
The following guide will help locate and correct ignition system-related starting problems.

PROBLEM	TEST	CONCLUSION
ENGINE WILL NOT START	1. Make sure spark plug leads are connected to spark plugs.	
	2. Check condition of spark plugs. Make sure gaps are set to .025.	If plugs are in good condition, check/adjust gaps and reinstall.
	3. Check ignition module using ignition system tester. a. Remove the high-tension leads from the engine spark plugs, and connect them to the test plugs. NOTE: To maintain engine speeds normally normally obtained during cranking, do not remove the engine spark plugs. b. Make sure the engine ignition switch (kill switch) and/or keyswtich are in the "run" position. c. Crank the engine and observe the test plugs. Visible and audible sparks should be be produced.	If visible and audible sparks ARE produced, the ignition module is OK. If visible and audible sparks ARE NOT produced: a. Make sure engine ignition switch and/or keyswitch are in the "run" position. b. Check wires and terminals of ignition module and other components for accidental grounding and/or damaged insulation. c. If wires and terminals are OK, the ignition module is probably faulty and should replaced. Test module further using an ohmmeter (Test 4).
	NOTE: Use a low-voltage ohmmeter when ohmmeter is required. Always zero ohmmeter on each scale before testing to ensure accurate readings.	
	4a. Measure the primary resistance of module using an ohmmeter. NOTE: Connect negative (-) lead of ohmmeter to kill terminal B. **Primary Leads/Terminals**: A - B **Primary Resistance**: 1.0/1.5 ohms	If resistance is low or 0 ohms, module primary is shorted. Replace module. If resistance is high or infinity ohms, module primary is open. Check keyswitch/wiring for shorts or connections which could apply 12V to kill terminal B. Correct those conditions, then replace module. If resistance is within range, module primary is OK. Test secondary (Test 4b).
	4b. Measure the secondary resistance of module using an ohmmeter. **Secondary Leads/Terminals**: C - D **Secondary Resistance**: 22,000/42,000 ohms	If resistance is within range, module secondary is OK. If resistance is low or 0 ohms, module secondary is shorted. Replace module. If resistance is high or infinity ohms, module secondary is open. Replace module.

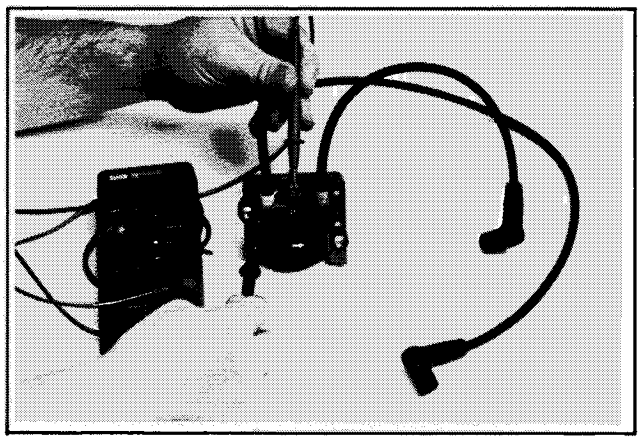
Ignition System Tester

A simple tester can be constructed to determine if the ignition module is functioning properly.

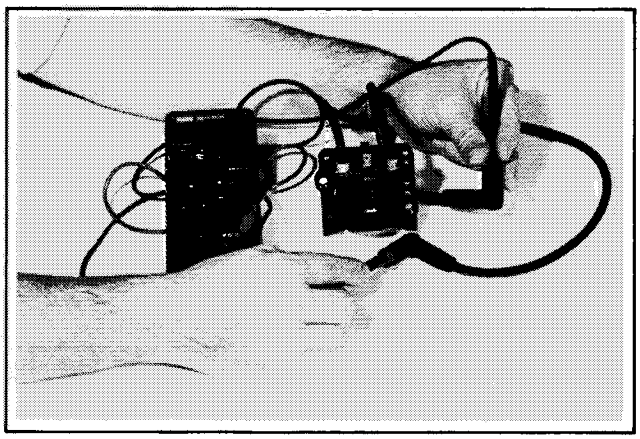
1. Use the same tester that was made for testing single cylinder modules.
2. Obtain another new RJ-8 or RCJ-8 spark plug, set gap at .025.
3. Obtain another large spring clip.
4. Attach the spring clip to the new spark plug, connect the alligator clip from the single cylinder tester to the terminal end of the spring clip.
5. Install another 1-1/4" length of 1/2" I.D. fuel line on the threads of the new plug.



Ignition System Tester - Twin Cylinder Engines



Testing Module Primary - Twin Cylinder Engines



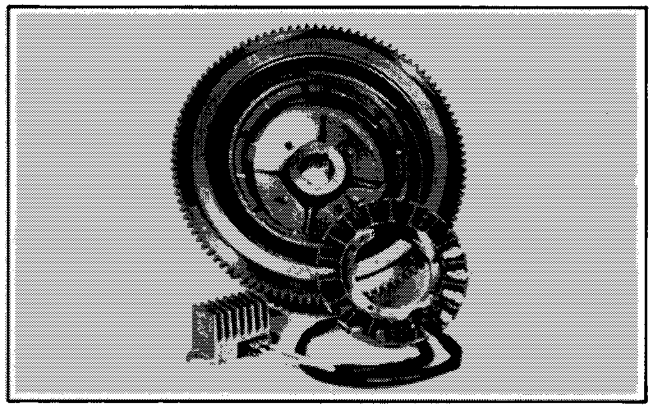
Testing Module Secondary - Twin Cylinder Engines

CHARGING SYSTEMS

The engines which use battery ignition usually have electric start also. Depending upon the application, there may be accessories or lights running off the battery as well. With all the demands put on the battery, provision must be made for recharging or the energy available would soon be depleted.

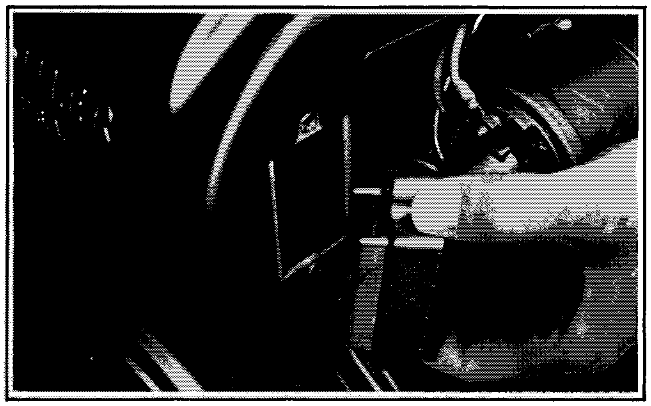
There are currently several different flywheel alternator systems used on Kohler engines for battery recharging. The following information will help you to identify the various systems.

The 15 amp system, which is the most common, incorporates a flywheel with six ceramic magnets cemented to the inside rim, an alternator stator ring, and a rectifier regulator which may be externally mounted (long fins, 3 terminals in offset configuration), or . . .



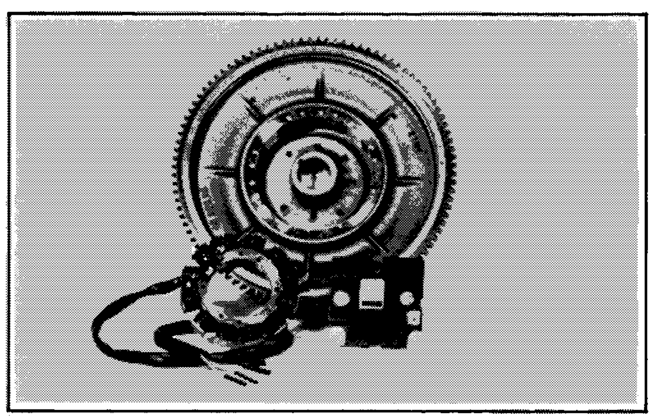
15 Amp Charging System/Externally Mounted Rectifier-Regulator

may mount directly into the blower housing (2 short fins, 3 terminals in line).



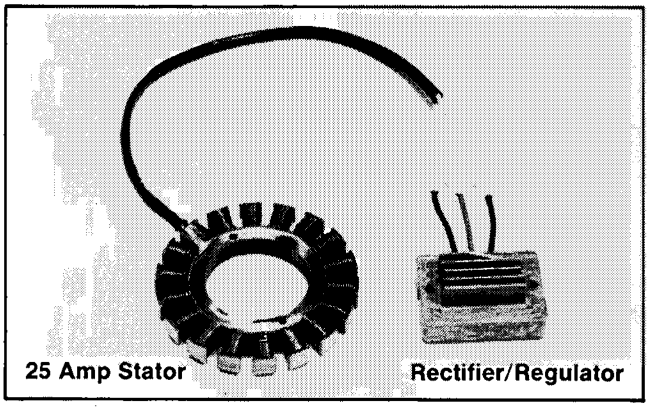
Blower Housing Mounted 15 Amp Rectifier-Regulator

For those O.E.M. accounts that needed more than 15 amp. charging, we offered a 30 amp. system. This system had a flywheel with a magnet ring assembly pressed in, an alternator stator with two separate sets of windings wound in opposite directions on the same posts, and a plate style regulator.



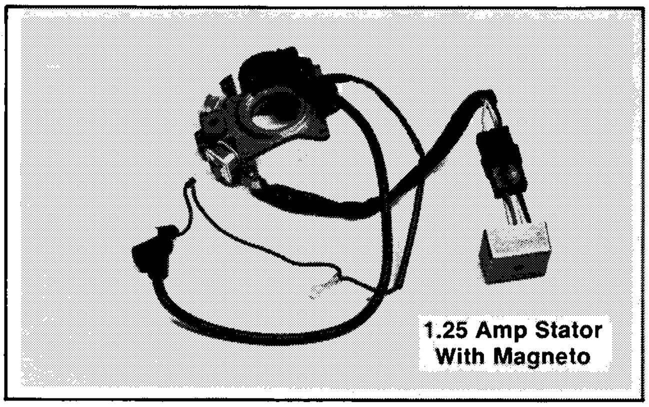
30 Amp Charging System

The 30 amp. system is being phased out in favor of a new 25 amp. system. The 25 amp. system uses the same flywheel as a 15 amp. system. The stator and rectifier-regulator are slightly different dimensionally, but will interchange with their 15 amp. counterparts.



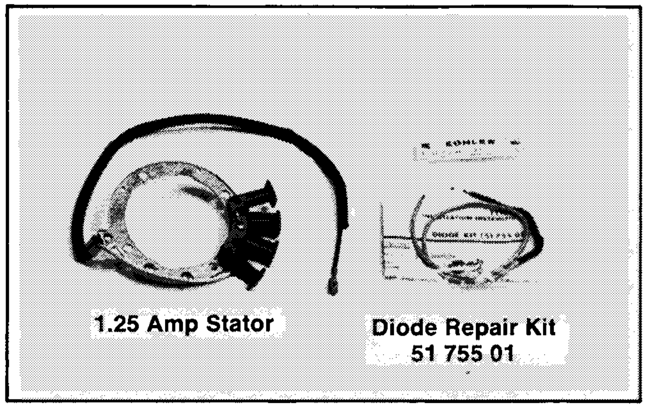
25 Amp Charging System

The 1.25 amp. stator with magneto was used on K181ST engines installed on Troy-Bilt tillers during 1984 and 1985. It used an externally-mounted recitifer.

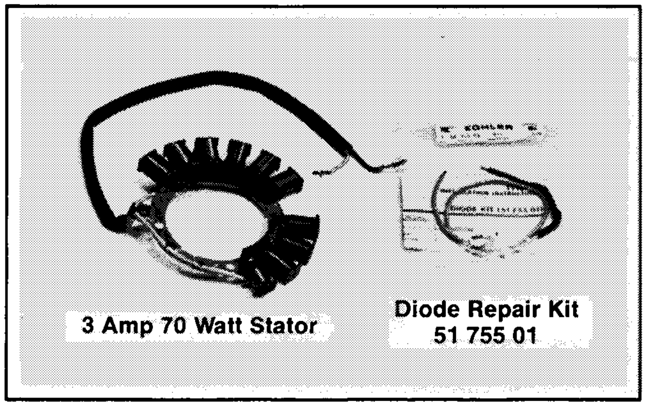


Ignition Magneto/1.25 Amp Unregulated Charging System

For those applications which need minimal battery charging capacity (electric start only, no accessories), we now offer the 1.25 and 3 amp. systems with optional 70 watt AC output for lighting or accessories. By using different configurations of the same basic stator we get four possible combinations. The flywheel used is similar to the 15 amp. flywheel, but it has one less magnet.



1.25 Amp Unregulated Charging System

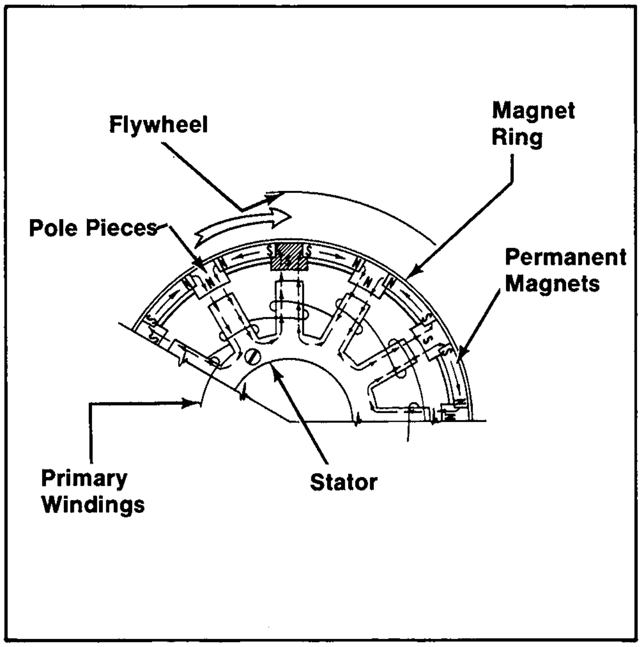


3 Amp Unregulated Charging System/70 Watt Lighting Stator

Charging System Theory And Function

The charging systems all function according to the same theory to provide the initial alternating current. The stators all have a core with 2 or more posts wound with copper windings. The permanent magnets in the flywheel are mounted with like poles together.

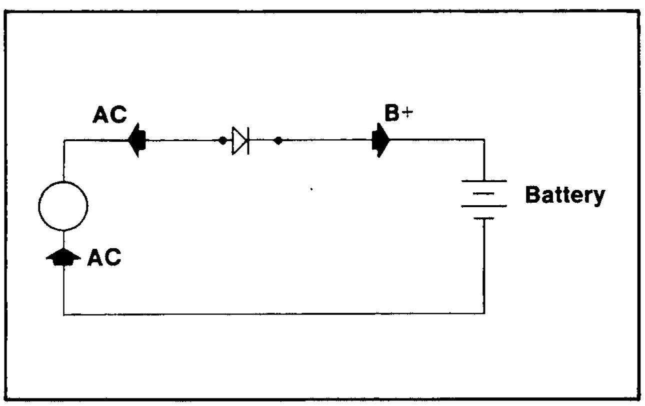
When the south poles align with a stator post, magnetic flux will travel through the stator in one direction. The flux lines "cut" the windings and the induced current will flow in one direction. As the flywheel rotates, the north poles will align over the post, the flux will reverse direction and the induced current will also reverse direction. As long as the flywheel continues rotating, the current will continue reversing, thus the term "alternating current" or AC.



Stator Operation

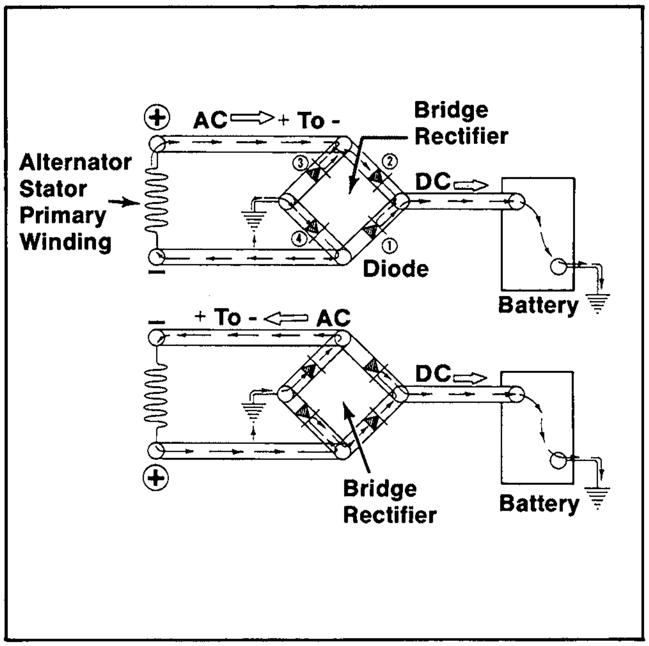
The current required for battery charging or ignition is direct current (DC), so the AC from the stator windings must be changed to DC before it can be used for battery charging. This is done by using solid state electronic devices called diodes. A diode, when placed in an electrical circuit will allow current to pass in one direction, but not the other. If we place a single positive diode in an AC circuit, the diode will allow current to flow only on the positive alternation and would block the return or negative alternation. This would be called a half wave rectifier since only 1/2 of the current produced would be available as interrupted or pulsating DC.

The 15 amp., 25 amp., 1.25 amp., and 3 amp. systems all use half-wave rectification.



Half-Wave Rectification

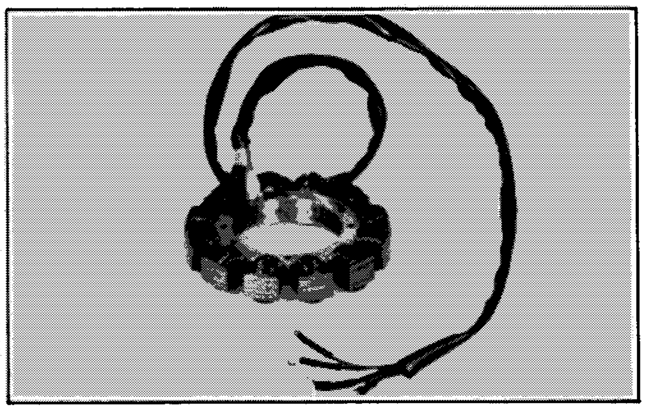
The 30 amp. system and the 1.25 amp. system use a full wave rectifier. By using four diodes and arranging them to form an electrical bridge, both positive and negative alternations can be rectified into a relatively smooth, unidirectional flow of DC.



Full Wave Bridge Rectifier

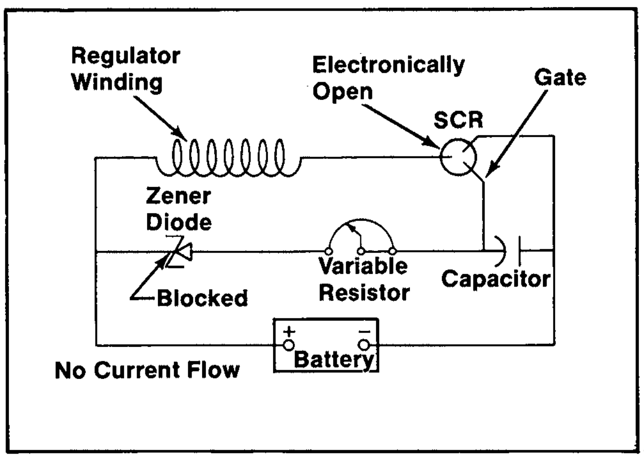
Once converted from AC to DC, the current can be used for battery charging. The 1.25 and 3 amp. systems have such low charge rates that the current goes directly to the battery after rectification. With the 15, 25, and 30 amp. systems, however, a regulating circuit must be used in conjunction with the rectifier, as these 3 systems have enough charging capacity to "boil" the electrolyte in the battery if the charging rate is not controlled.

It was stated earlier that the 30 amp. system has two sets of windings on the alternator stator. One set of windings (heavy wire with black insulation) is where our AC current is generated. The other set (finer wire with red insulation) is the regulator winding.



30 Amp Charging System

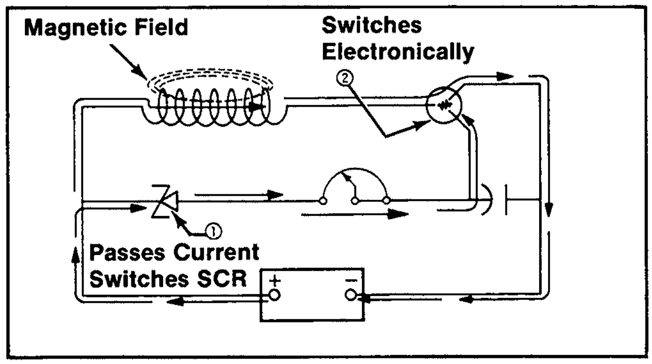
The regulator winding is connected to a regulator circuit in the rectifier regulator module which includes a zener diode, a silicon controlled rectifier (SCR), a variable resistor and a capacitor. When the battery is low and in need of charging, the regulating circuit does not function and the battery is charged at full capacity by the alternator. During this time the zener diode blocks any current flow into the regulator circuit.



No Regulation - Battery Voltage Less Than "Breakdown" Voltage of Zener Diode

When the battery comes up to charge and the battery voltage exceeds the "breakdown" voltage of the zener diode, current will flow through the variable resistor to the "gate" or control element of the SCR. When the gate voltage exceeds the ground side voltage, the SCR switches electronically to complete the regulating circuit and current flows into the regulator windings of the stator.

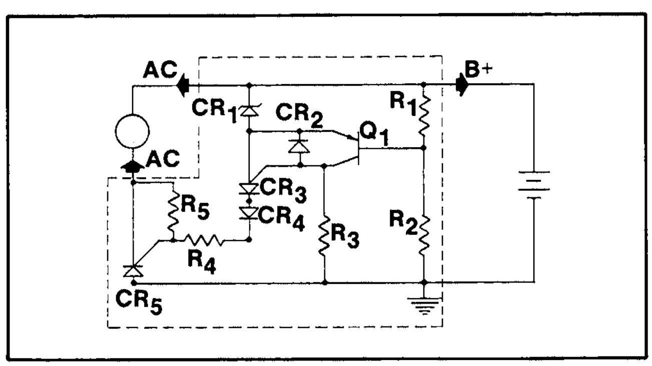
The regulator windings are wound in the opposite direction of the AC windings, so when current flows through the regulator windings the magnetic field established around the regulator windings will counteract the field of the AC windings to control the AC output, and thus control the charge to the battery.



Regulation - Battery Voltage Exceeds "Breakdown" Voltage Of Zener Diode

In the 15 amp. system, rectification and regulation is performed by the same circuit. The outer circuit in our schematic consists of the alternator stator, the battery, and CR5 which is a programmable unijunction transistor (PUT). The PUT functions as both a diode and an SCR. In its function as a diode, it provides our 1/2 wave rectification. In its function as an SCR, it controls the flow of current in our charging circuit.

The inner portion of the circuit controls the flow of current to the "gate" of the PUT. Again, we have a zener diode which functions as a voltage sensing device. The zener diode is connected to the cathode of transistor Q1. The anode is connected across the battery through resistors R1 and R2, so it will receive a voltage proportional to the battery voltage. The transistor continuously monitors or "compares" the voltages at its anode and cathode. When the battery voltage drops below the desired regulation voltage, the reference voltage reaching the cathode from the zener diode will exceed the voltage at the anode, and current will flow from the anode through the gate terminal to the "gate" of the PUT. The PUT switches electronically to complete the charging circuit and charge the battery. When the battery comes up to full charge and the anode voltage exceeds the cathode voltage at transistor Q1, current to the gate of the PUT will be cut off, and the PUT will block the flow of current in the charging circuit.



Regulator - Rectifier Circuit Schematic

By now, we hope you have gained a basic understanding of the functional theory of the ignition and charging systems. If you have, it should help you when troubleshooting and diagnosing problems in these areas. To further assist you, the following pages contain wiring diagrams and troubleshooting charts for the various charging systems.

1.25 Amp. Unregulated Battery Charging System With Magneto

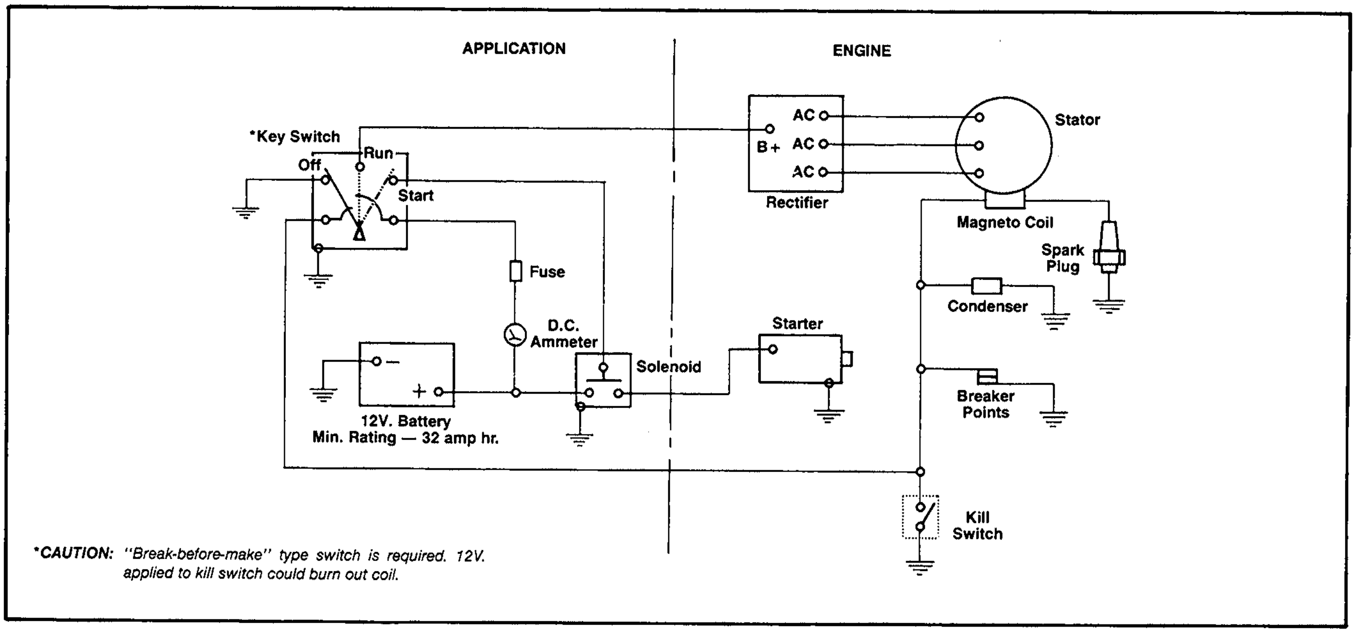
The 1.25 amp alternator system is designed to charge a 12 volt lead-acid storage battery with a minimum rating of 32 amp. hr. while reducing battery maintenance to a minimum. It is for applications that have the electric starter as the only battery load.

This system consists of three major components: a group of two die cast magnets which are affixed to the inner rim of the flywheel, the magneto coil/alternator stator mounted on the engine crankcase, and a full-wave rectifier unit.

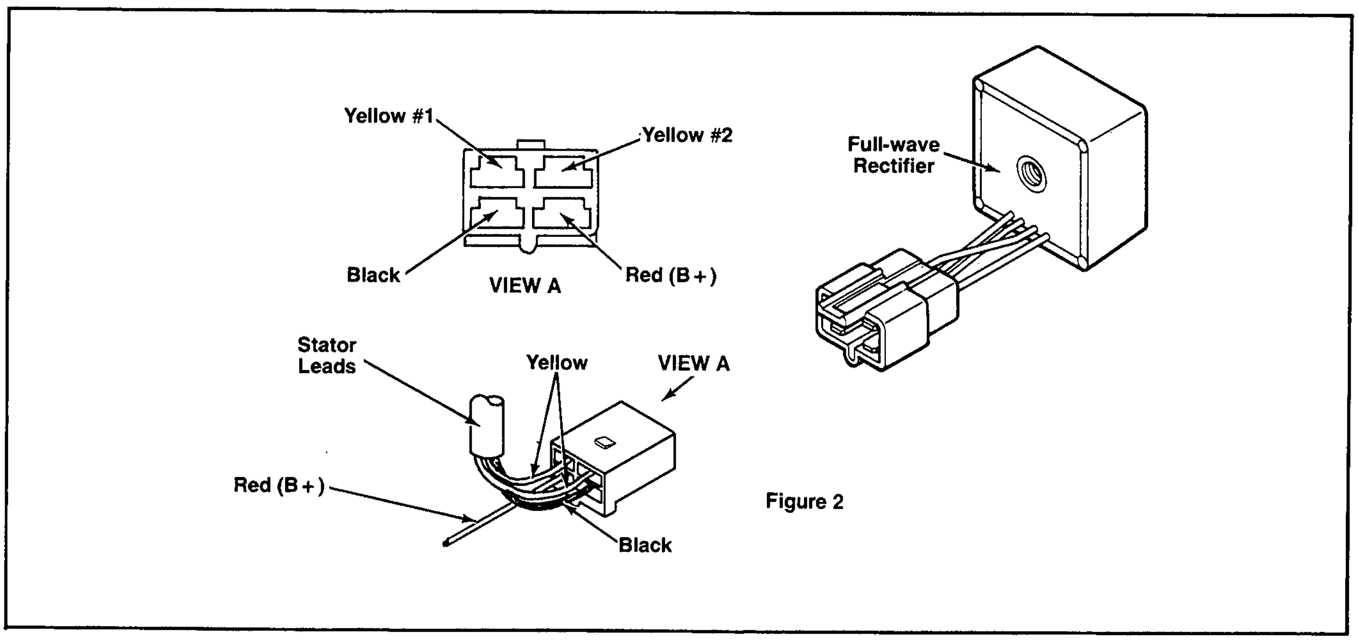
Refer to the following 1.25 Amp System Service Guide when servicing the system.

CAUTION:

1. *Make sure battery polarity is correct. Negative ground systems are used.*
2. *Prevent stator leads (AC) from touching or shorting. Touching or shorted leads could permanently damage the stator.*
3. *Disconnect leads at rectifier before electric welding is done on equipment in common ground with the engine.*



Wiring Diagram - 1.25 Amp Unregulated Battery Charging System With Magneto



1.25 Amp Rectifier

Troubleshooting Guide
1.25 Amp Unregulated Battery Charging System With Magneto

NOTE: Always zero meters on each scale before testing to ensure accurate readings.

<table>
<tr><th>Problem</th><th>Test</th><th>Conclusion</th></tr>
<tr><td rowspan="5">BATTERY NOT CHARGING</td><td>1. Check for and correct poor or corroded connections, and broken wires.</td><td></td></tr>
<tr><td>2. Check condition of battery. Make sure it will accept and hold a charge.</td><td>If battery is in poor condition—recharge or replace battery.

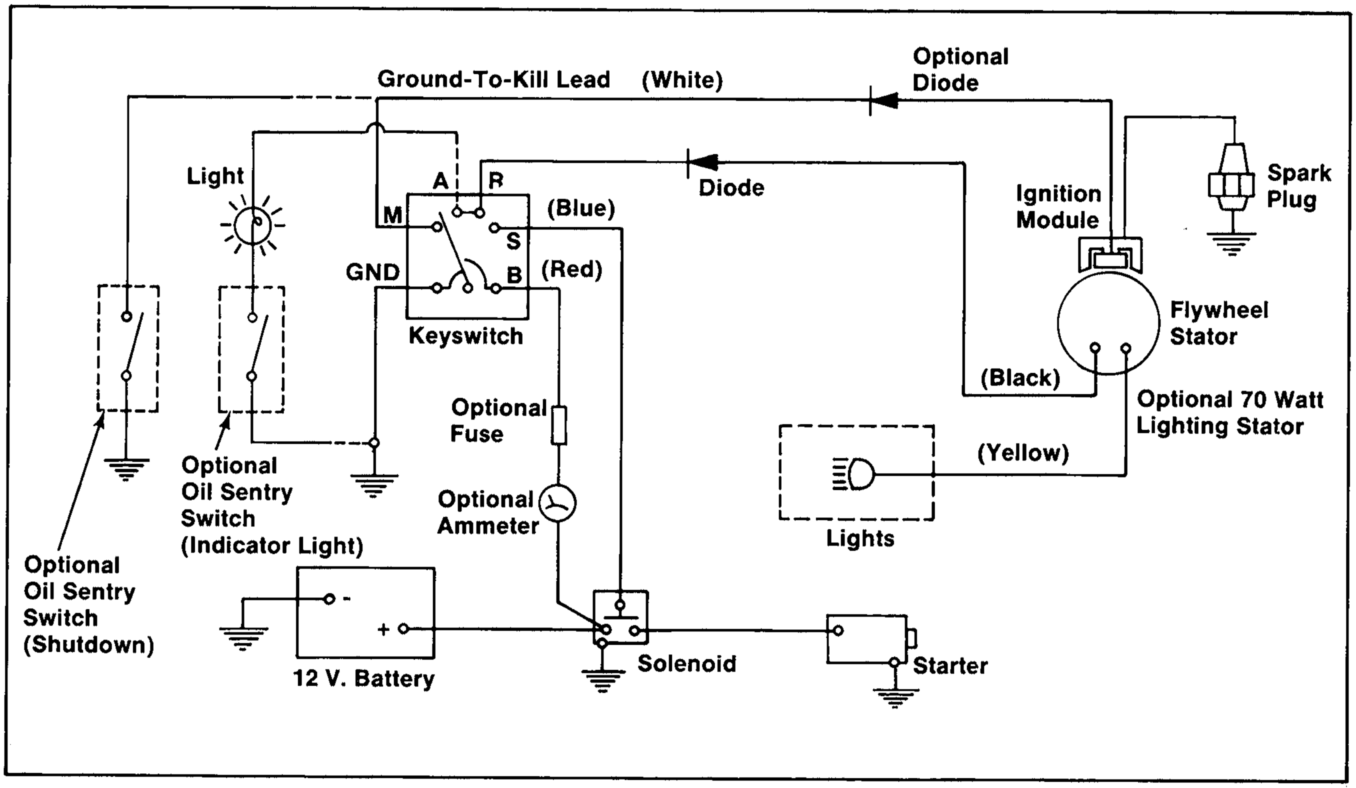
If battery is in good condition—check for B+ Voltage (Test 3).</td></tr>
<tr><td>3. Disconnect B+ lead from battery. With engine running at 3200 RPM, measure D.C. voltage from B+ to ground.
Lead — D.C. Voltage Specification
B+ -GND — 12.6-20.4 volts</td><td>If D.C. Voltage is low, or if no voltage is present—
check for faulty rectifier or stator (Test 4).</td></tr>
<tr><td>4a. Disconnect stator leads (plug) from rectifier. With engine running at 3200 RPM, measure A.C. voltage of stator across the following leads.
(Refer to Figure 2, "View A.")
Lead — A.C. Voltage Specification
Yellow #1-Yellow #2 — 13.9-23.0 volts
Yellow #1-Black — 7.3-11.6 volts
Yellow #2-Black — 7.3-11.6 volts</td><td>If A.C. voltage is within ranges stated, and D.C. voltage measured in test 3 was low or 0 volts—
rectifier is faulty and should be replaced.
If A.C. voltage is low or 0 volts—
stator is probably faulty. Test stator further using an ohmmeter (Test 4b).</td></tr>
<tr><td>4b. Measure resistance of stator windings across the following leads using an ohmmeter. (Refer to Figure 2, "View A.")
Lead — Resistance Specification
Yellow #1-Yellow #2 — 2.5-3.5 ohms
Yellow #1-Black — 1.2-1.8 ohms
Yellow #2-Black — 1.2-1.8 ohms

Also check for continuity across each lead and and the laminated stator core.</td><td>If resistance is within ranges stated—
stator is O.K.

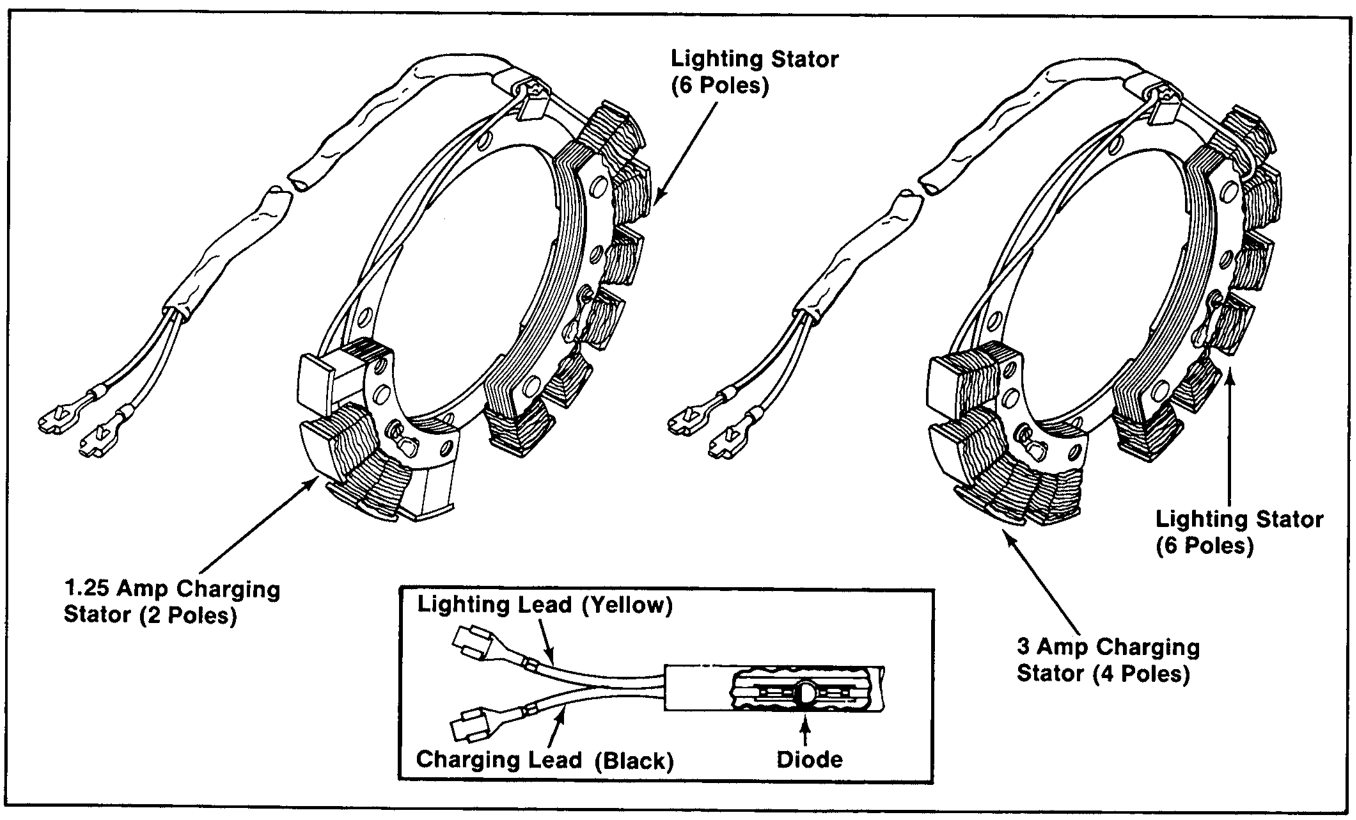
If resistance is low or 0 ohms—
stator is shorted and should be replaced.
If resistance is infinity ohms—
stator windings or lead is open. Stator should be replaced.

If continuity is present across leads stator core—
stator windings are shorted to core. Stator should be replaced.</td></tr>
</table>

Electric Start Engines
1.25 Amp Or 3 Amp Unregulated Battery Charging System
Optional 70 Watt Lighting



Wiring Diagram - Electric Start Engines 1.25 Amp or 3 Amp Unregulated Battery Charging System/70 Watt Lighting



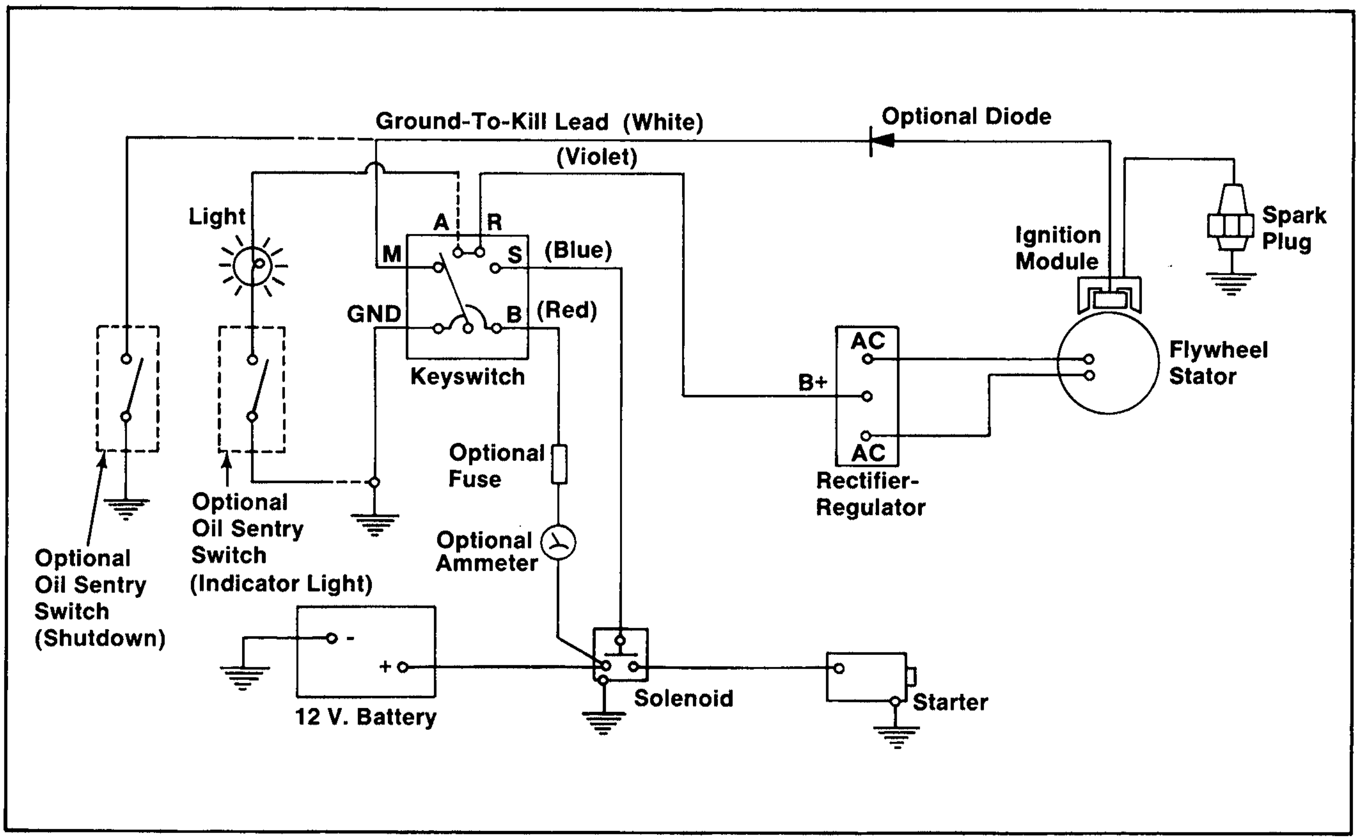
1.25 Amp or 3 Amp/70 Watt Lighting Stator

Troubleshooting Guide
1.25 Amp Or 3 Amp Unregulated Charging System
Optional 70 Watt Lighting

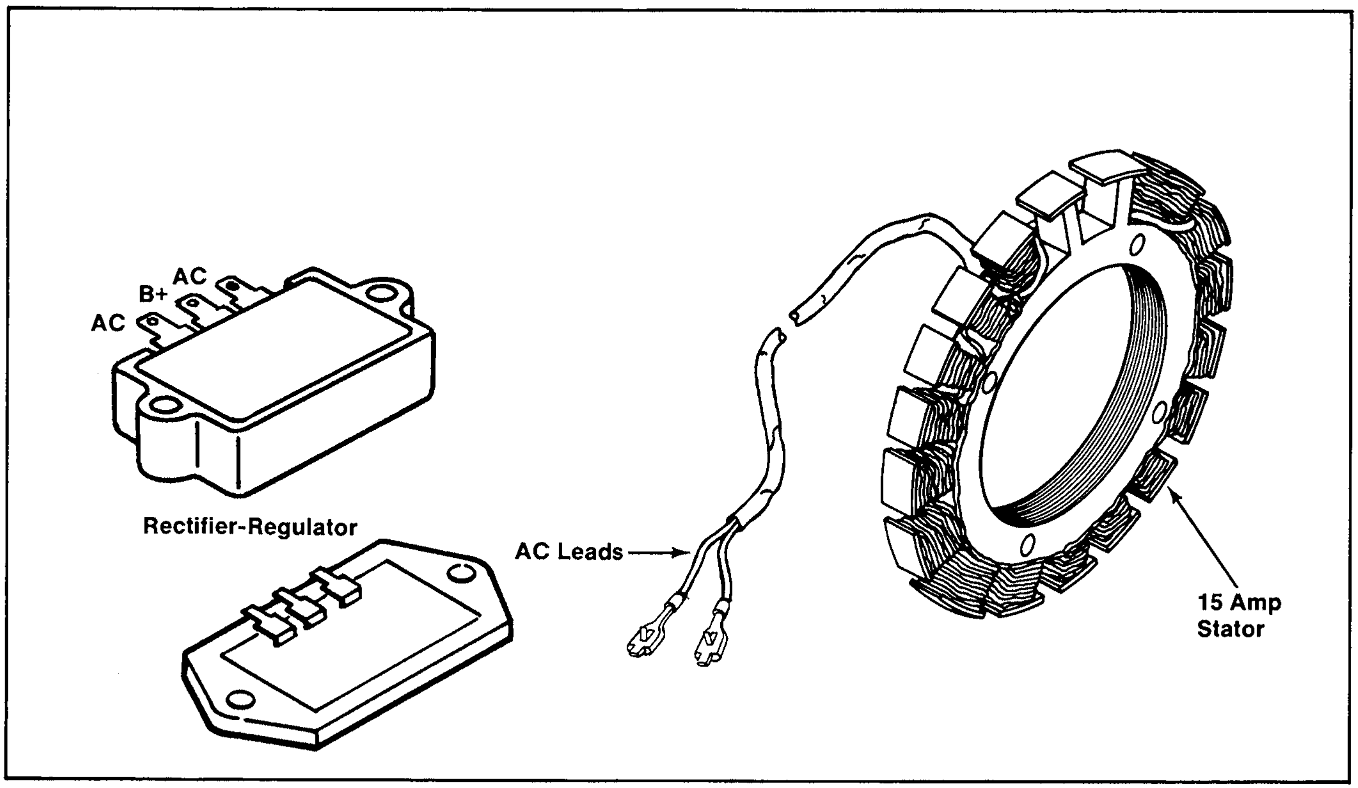
NOTE: Zero ohmmeters and voltmeters on each scale to ensure accurate readings. Voltage test should be made with engine running at 3000 RPM -no load. Battery must be fully charged.

Problem	Test	Conclusion
NO CHARGE TO BATTERY	1. With engine running at 3000 RPM, measure voltage across battery terminals using a DC voltmeter.	1. If voltage is more than 12.5 volts, charging system is OK. If voltage is 12.5 volts or less, the stator or diode are probably faulty. Test the stator and diode (Test 2, 3, and 4).
	2. Disconnect the charging lead from battery. With engine running at 3000 RPM, measure voltage from charging lead to ground using a DC voltmeter.	2. a. 1.25 amp. If voltage is 11.5 volts or more stator winding is OK. b. 3 amp. If voltage is 28 volts or more, stator winding is OK. If voltage is less than specified test stator using an ohmmeter (Tests 3 and 4).
	3. With charging lead disconnected from battery and engine stopped, measure resistance from charging lead to ground using an ohmmeter. Note reading. Reverse the leads and measure resistance again. In one direction, the resistance should be infinity ohms (open circuit). With the leads reversed, some resistance should be measured (about midscale on Rx1 range).	3. If resistance is low in both directions, the diode is shorted. Replace the diode. If resistance is high in both directions, the diode or stator winding is open. (Use Test 4).
	4. Cut the sleeving on the charging lead to expose the diode connections. Measure the resistance from the stator side of diode to ground using an ohmmeter.	4. If resistance is 0.7/1.3 ohms, stator winding is OK. If resistance is 0 ohms, stator winding is shorted. Replace stator. If resistance is infinity ohms, stator winding or lead is open. Replace stator.
NO LIGHTS	1. Make sure lights are not burned out.	1. Replace burned out lights.
	2. Disconnect the lighting lead from the wiring harness. With engine running at 3000 RPM, measure voltage from lighting lead to ground using an AC voltmeter.	2. If voltage is 15 volts or more, stator is OK. Check for loose connections or shorts in wiring harness. If voltage is less than 15 volts, test stator using an ohmmeter (Test 3).
	3. With engine stopped, measure the resistance of stator from lighting lead to ground using an ohmmeter.	3. If resistance is approx. 0.4 ohms, stator is OK. If resistance is 0 ohms, stator is shorted. Replace stator. If resistance is infinity ohms, stator or lighting lead is open. Replace stator.

Electric Start Engines
15 Amp Regulated Battery Charging System



Wiring Diagram - Electric Start Engines/15 Amp Regulated Battery Charging System



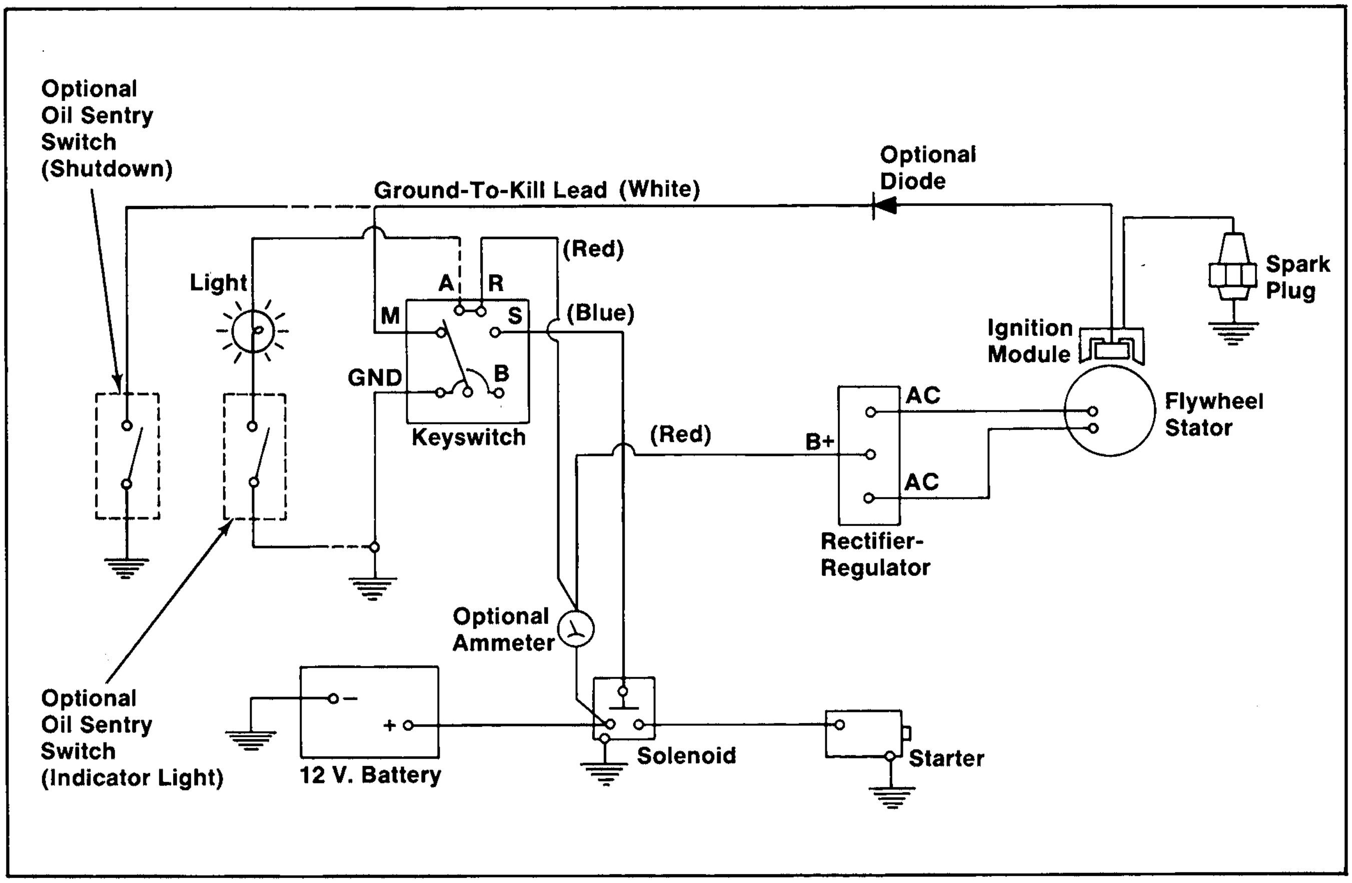
15 Amp Stator And Rectifier-Regulator

Troubleshooting Guide
15 Amp Battery Charging System

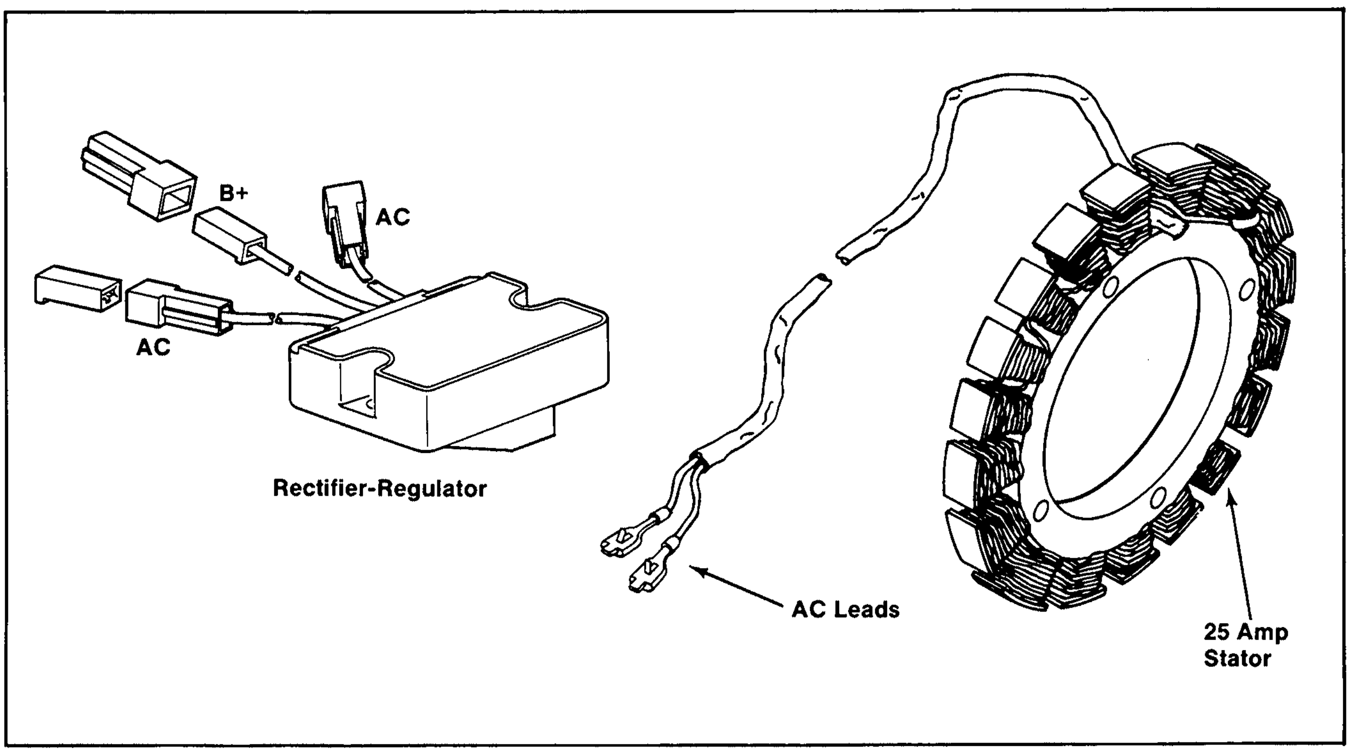
NOTE: Zero ohmmeters and voltmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3600 RPM - no load. Battery must be fully charged.

Problem	Test	Conclusion
NO CHARGE TO BATTERY	1. Insert an ammeter in B+ lead from rectifier-regulator. With engine running at 3600 RPM and B+ lead connected, measure the voltage from B+ (at terminal on rectifier-regulator) to ground using a DC voltmeter. If voltage is 13.8 volts or more, place a minimum load of 5 Amps* on battery to reduce voltage. Observe ammeter. *NOTE: Turn on lights, if 60 watts or more. Or place a 2.5 ohm, 100 watt resistor across battery terminals.	1. If charge rate increases when load is applied, the charging system is OK and battery was fully charged. If charge rate does not increase when load is applied, test stator and rectifier-regulator (tests 2 and 3).
	2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is 28 volts or more, stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator. If voltage is less than 28 volts, stator is probably faulty and should be replaced. Test stator further using an ohmmeter (test 3).
	3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.	3a. If resistance is 0.1/0.2 ohms, the stator is OK. If resistance is infinity ohms, stator is open. Replace stator.
	3b. With engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If resistance is infinity ohms (no continuity), the stator is OK (not shorted to ground). If resistance (or continuity) is measured, the stator leads are shorted to ground. Replace stator.
BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	1. With engine running at 3600 RPM, measure voltage from B+ lead to ground using a DC voltmeter.	1. If voltage is 14.7 volts or less the charging system is OK. The battery is unable to hold charge. Service battery or replace as necessary. If voltage is more than 14.7 volts, the rectifier-regulator is faulty. Replace rectifier-regulator.

Electric Start Engine
25 Amp Regulated Battery Charging System



Wiring Diagram - Electric Start Engines/25 Amp Regulated Battery Charging System



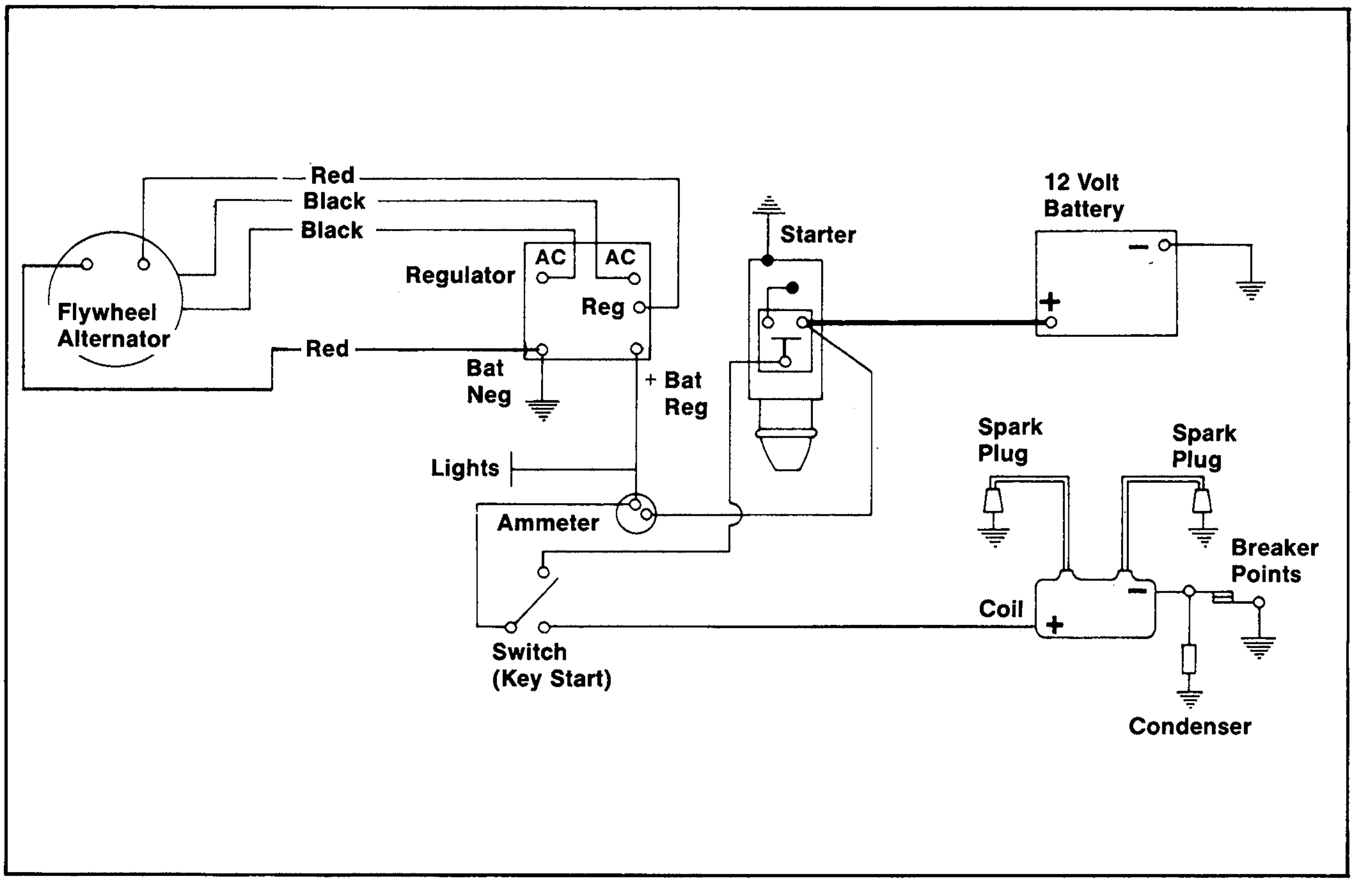
25 Amp Stator And Rectifier-Regulator

Troubleshooting Guide
25 Amp Battery Charging System

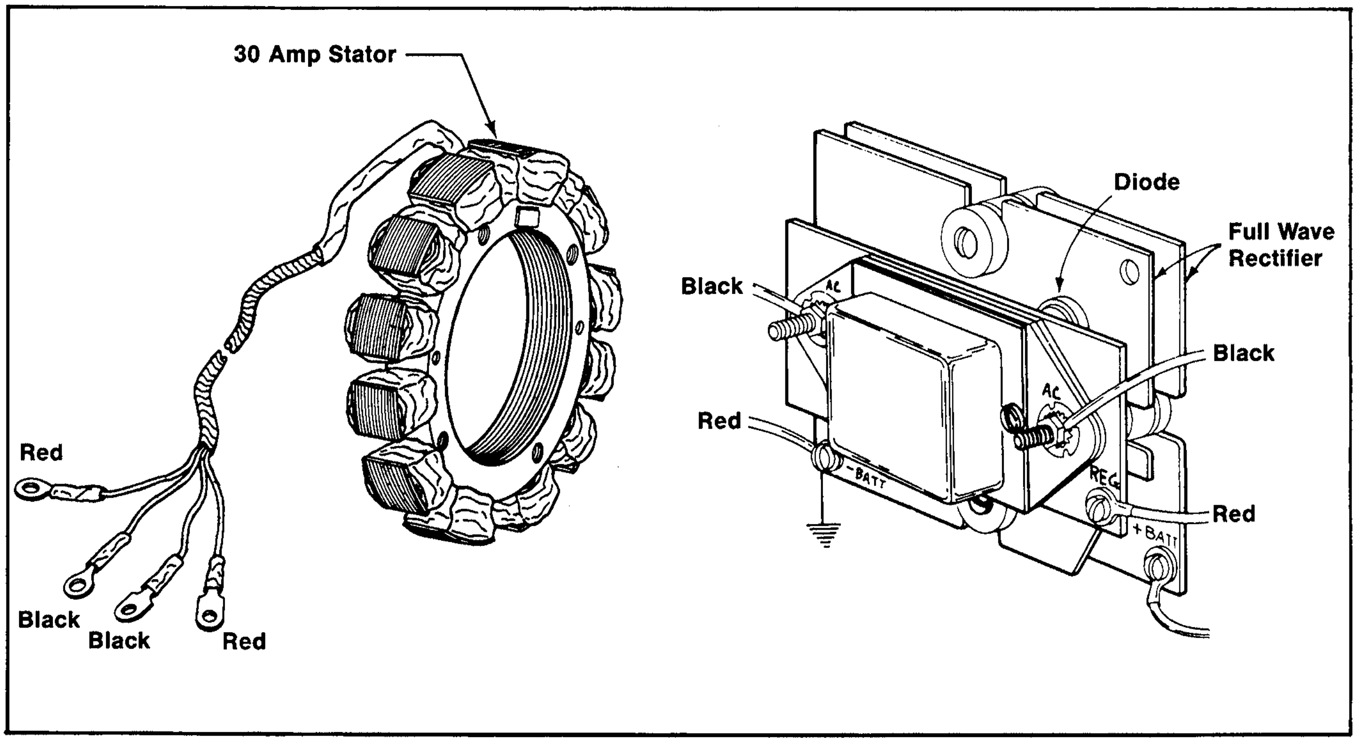
NOTE: Zero ohmmeters and voltmeters on each scale to ensure accurate readings. Voltage tests should be made with engine running at 3600 RPM - no load. Battery must be fully charged.

Problem	Test	Conclusion
NO CHARGE TO BATTERY	1. Insert an ammeter in B+ lead from rectifier-regulator. With engine running at 3600 RPM and B+ lead connected, measure the voltage from B+ (at terminal on rectifier-regulator) to ground using a DC voltmeter. If voltage is 13.8 volts or more, place a minimum load of 5 Amps* on battery to reduce voltage. Observe ammeter. *NOTE: Turn on lights, if 60 watts or more. Or place a 2.5 ohm, 100 watt resistor across battery terminals.	1. If charge rate increases when load is applied, the charging system is OK and battery was fully charged. If charge rate does not increase when load is applied, test stator and rectifier-regulator (tests 2 and 3).
	2. Remove connector from rectifier-regulator. With engine running at 3600 RPM, measure AC voltage across stator leads using an AC voltmeter.	2. If voltage is 28 volts or more, stator is OK. Rectifier-regulator is faulty. Replace the rectifier-regulator. If voltage is less 28 volts, stator is probably faulty and should be replaced. Test stator further using an ohmmeter (test 3).
	3a. With engine stopped, measure the resistance across stator leads using an ohmmeter.	3a. If resistance is 0.064/0.096 ohms, the stator is OK. If resistance is infinity ohms, stator is open. Replace stator.
	3b. With engine stopped, measure the resistance from each stator lead to ground using an ohmmeter.	3b. If resistance is infinity ohms (no continuity) the stator is OK (not shorted to ground). If resistance (or continuity) is measured, the stator leads are shorted to ground. Replace stator.
BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	1. With engine running at 3600 RPM, measure voltage from B+ lead to ground using a DC voltmeter.	1. If voltage is 14.7 volts or less the charging system is OK. The battery is unable to hold charge. Service battery or replace as necessary. If voltage is more than 14.7 volts, the rectifier-regulator is faulty. Replace rectifier-regulator.

Electric Start
30 Amp Regulated Battery Charging System



Wiring Diagram - Electric Start Engines/30 Amp Regulated Battery Charging System



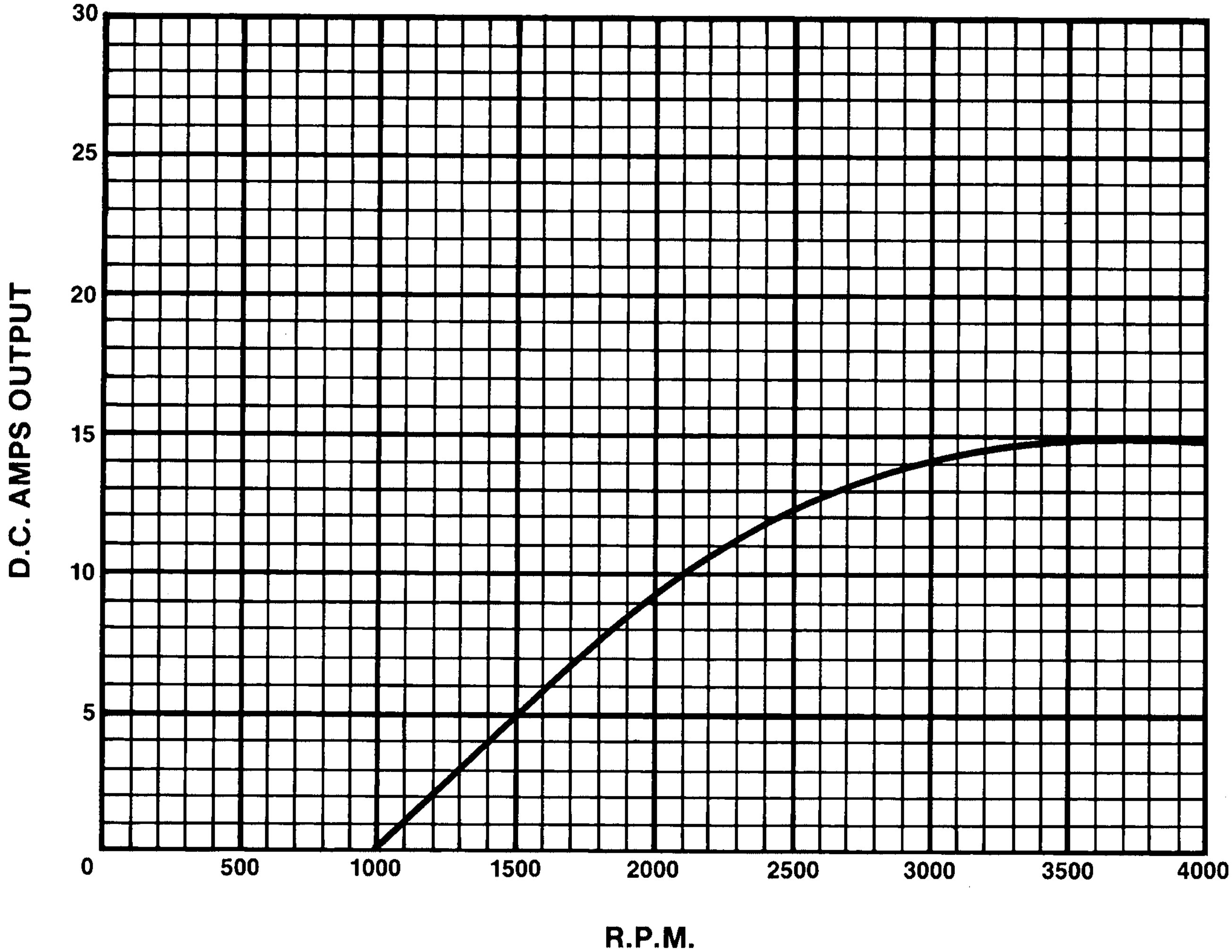
30 Amp Stator and Rectifier-Regulator

Troubleshooting Guide
30 Amp Regulated Battery Charging System

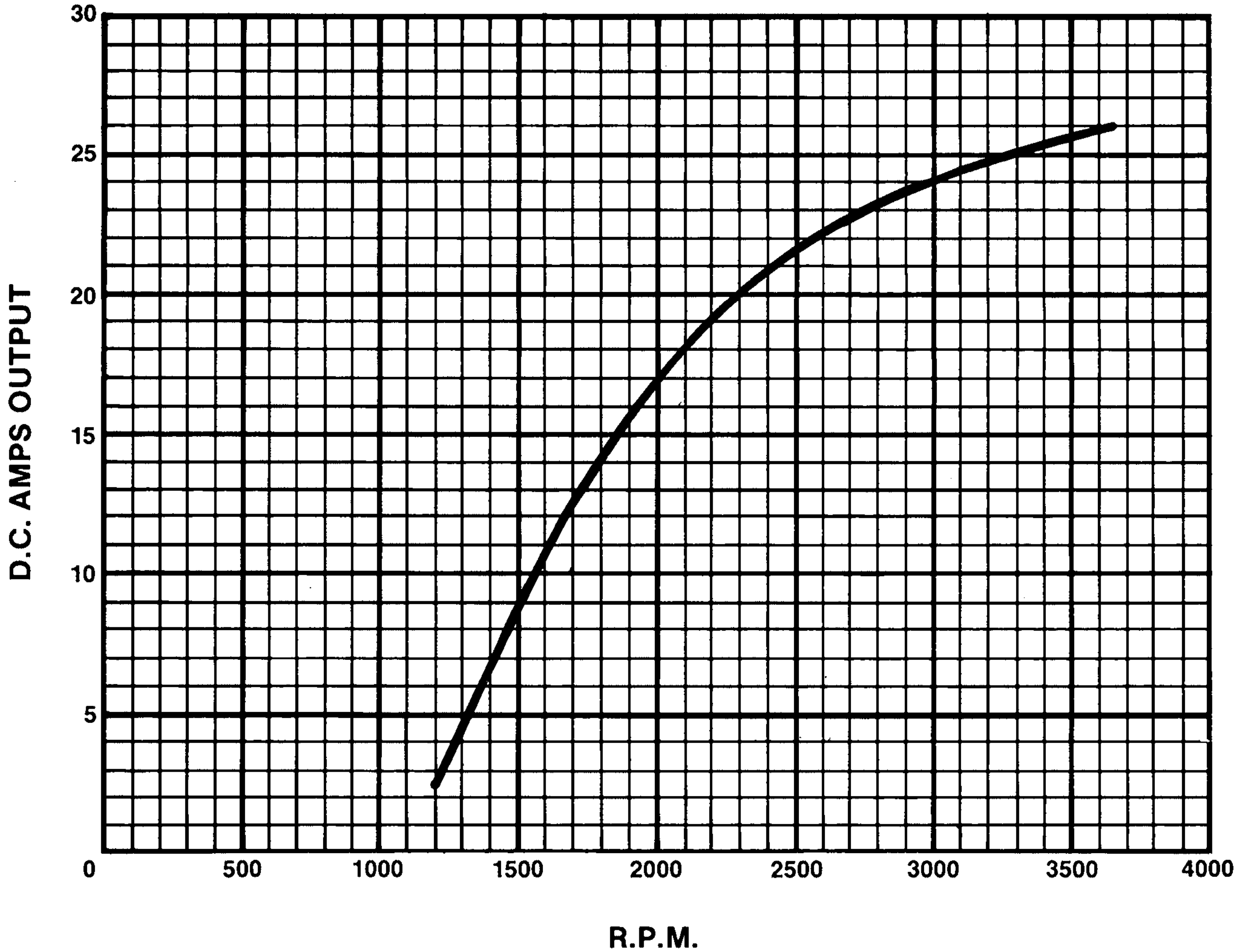
Output tests should be made with engine running at 3600 RPM - no load.
Battery must be fully charged.

Problem	Test	Conclusion
NO CHARGE TO BATTERY	Remove 4 input leads from rectifier-regulator. Set ohmmeter on Rx1 scale and zero scale.	
	1a. Connect ohmmeter across red leads and check resistance.	1a. Resistance should be 2.0 ohms.
	1b. Connect ohmmeter across black leads and check resistance.	1b. Resistance should be 0.1 ohms.
	1c. Measure the resistance from each stator lead to ground.	1c. Resistance should be infinity ohms (no continuity).
	Replace stator if specified values are not found.	
	2. Connect leads of flashlight type continuity tester from BAT NEG to one AC terminal, then reverse leads. Repeat procedure on the other AC terminal.	2. Lamp off in one direction, on when leads are reversed. Diodes in regulator are good. Replace rectifier-regulator if lamp indication is the same in both directions.
	3. Remove red lead from REG terminal (all other leads connected to appropriate terminals). If unit does not have ammeter, connect ammeter between + BAT REG terminal and battery. Start engine and operate at full speed.	3. Charging system output less 20 amps. Faulty regulator winding on stator, replace stator.
BATTERY CONTINUOUSLY CHARGES AT HIGH RATE	1. Remove two red leads from rectifier-regulator, connect these two leads together. Start engine and operate at full speed.	Charge rate is 4 amps or less. Stator is good. Replace rectifier-regulator. Charging system continues to charge at high rate. Regulator winding shorted, replace stator.

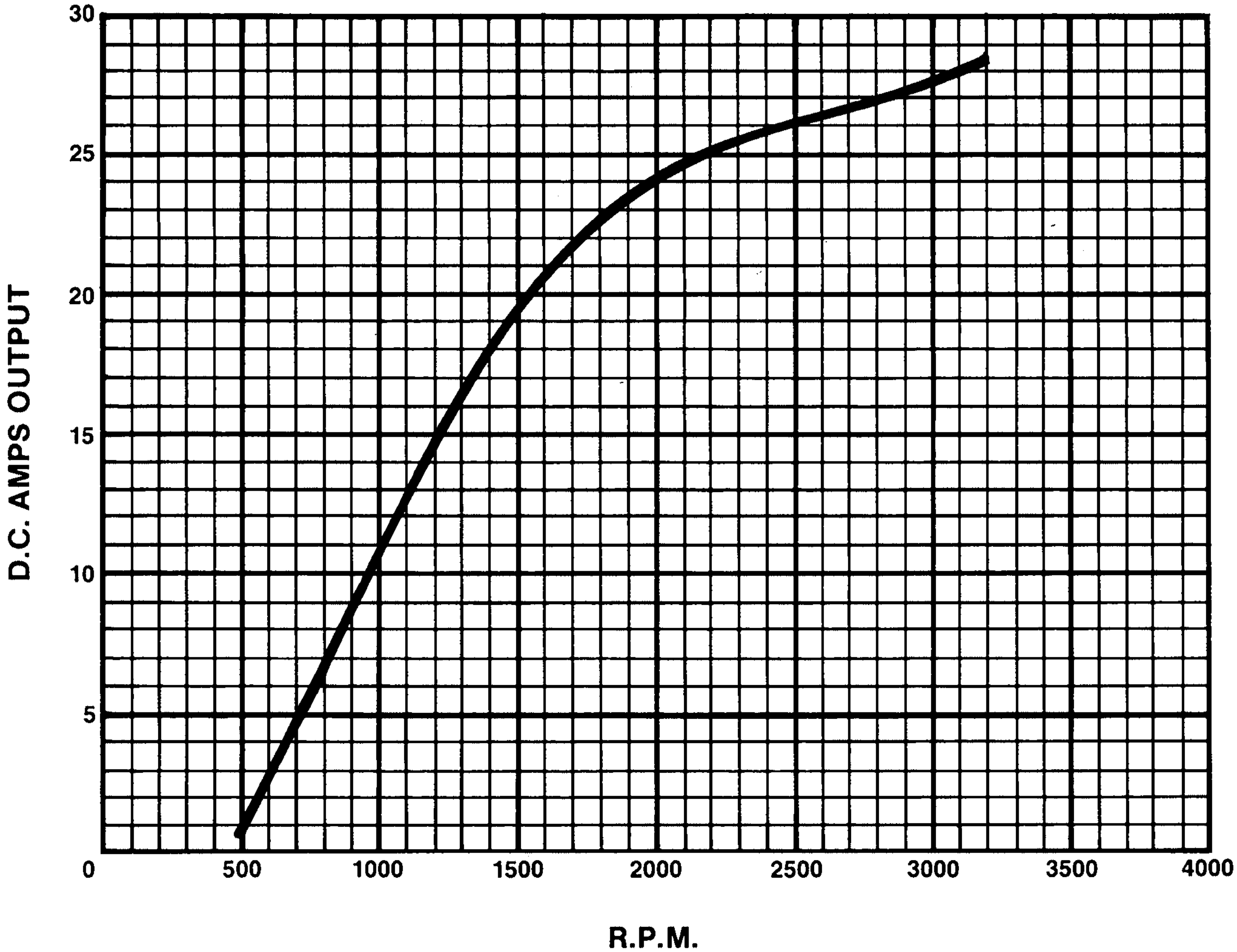
15 AMP ALTERNATOR
MAXIMUM OUTPUT



25 AMP ALTERNATOR MAXIMUM OUTPUT



30 AMP ALTERNATOR MAXIMUM OUTPUT



KOHLER® engines

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

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LITHO IN U.S.A.

PLEASE NOTE: This is a PRELIMINARY copy of the Carburetor Reference Manual.

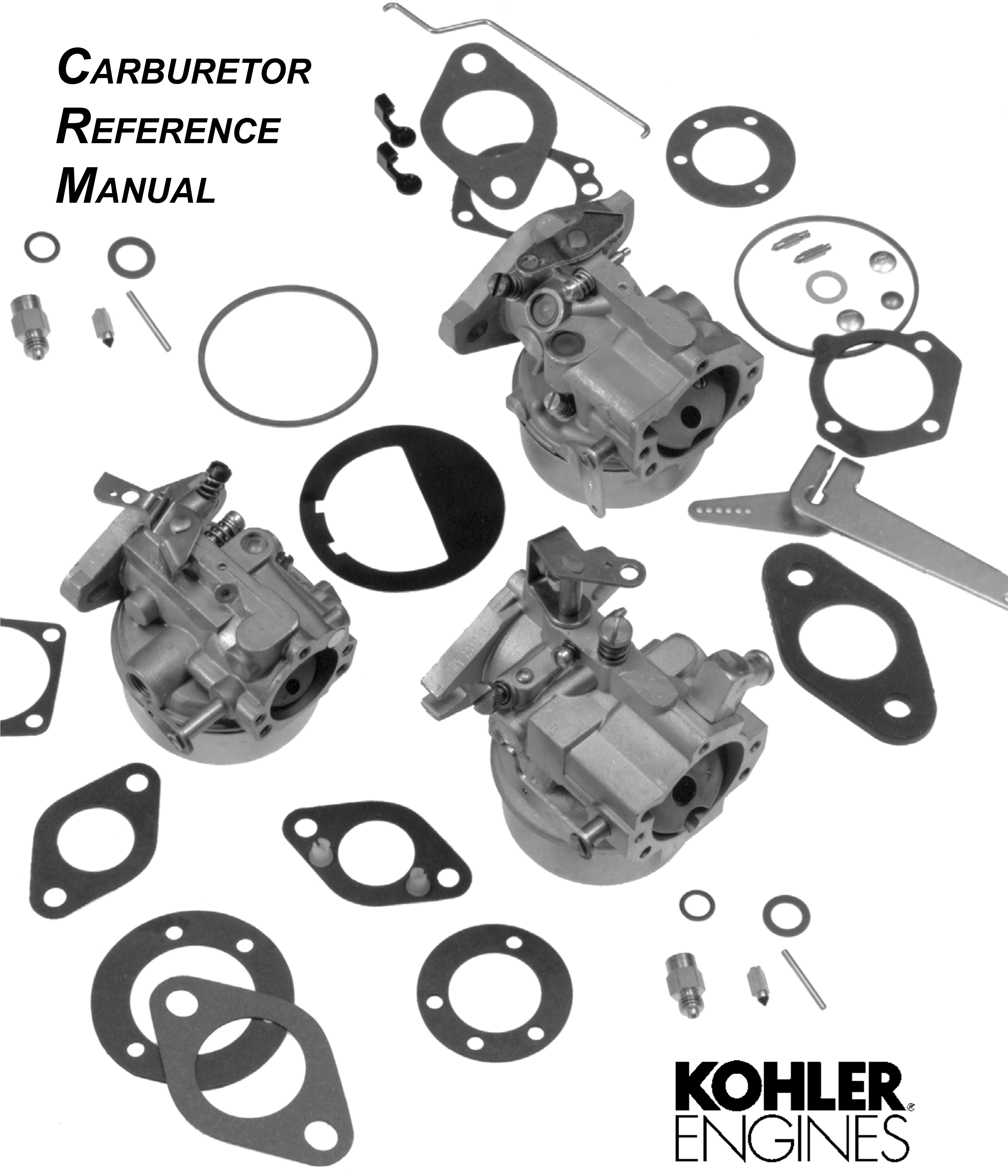
Carburetor Service Kits

The carburetors for most current production engines are serviced with convenient kits, which include the necessary gaskets, hardware, sealant, etc. The following table lists the service kits by engine model and carburetor manufacturer. For those carburetors where a float kit is not listed, order a rebuild kit which includes the float.

Engine Model	Carburetor Mfr.	Gasket Repl. Kit	Rebuild Kit	Float Kit	Choke Repair Kit Standard	Choke Repair Kit Self-Reliev.
CS4, 6	Mikuni		63 757 04-S	63 757 05-S		
CS8.5 (250cc)	Mikuni		63 757 10-S	63 757 08-S		
CS8.5-12	Mikuni		63 757 01-S	63 757 02-S		
CH6	Keihin	15 757 09-S	15 757 07-S		15 757 08-S	
CH/CV11-16	Walbro		12 757 03-S	12 757 02-S	12 757 08-S	
CH/CV11-16	Nikki	12 757 31-S	12 757 27-S		12 757 30-S	12 757 29-S
TH16, 18	Nikki	24 757 20-S	28 757 05-S	28 757 06-S	28 757 08-S	
CH18-25	Keihin		24 757 03-S	24 757 02-S	24 757 07-S	
CV17-25	Nikki	24 757 20-S	24 757 18-S		24 757 19-S	
CH/CV22/23 (674cc)	Keihin	24 757 38-S	24 757 46-S	24 757 44-S	24 757 36-S	
LV675-740	Nikki	24 757 20-S	24 757 18-S		24 757 19-S	

Engine Model	Carburetor Mfr.	Solenoid Kit	Fuel Bowl Repl. Kit	Accelerator Pump Kit(s) Seal & Bush.	Accelerator Pump Kit(s) Diaphragm
CS4, 6	Mikuni				
CS8.5 (250cc)	Mikuni				
CS8.5-12	Mikuni				
CH6	Keihin				
CH/CV11-16	Walbro	12 757 33-S	12 757 37-S		
CH/CV11-16	Nikki	12 757 28-S			
TH16, 18	Nikki	28 757 07-S			
CH18-25	Keihin	24 757 01-S		24 757 08-S	24 757 09-S
CV17-25	Nikki	24 757 22-S			24 757 21-S
CH/CV22/23 (674cc)	Keihin	24 757 45-S			24 757 47-S
LV675-740	Nikki	28 757 07-S			24 757 21-S

CARBURETOR REFERENCE MANUAL



KOHLER ENGINES

This reference manual contains information on the various types of carburetors used on Kohler engines. Section 1 is a part number cross reference to assist you in selecting the proper replacement carburetor or carburetor kit. Section 2 contains recommended carburetor adjustment procedures for Kohler and Walbro carburetors, and preliminary needle settings for all carburetors and engine models. Section 3 is a service parts listing.

The cross reference listing will be periodically updated to reflect part number supersessions. All information in this manual is subject to change. For additional service and repair information see the appropriate service manual for your model engine.

Section 1
Carburetor Cross Reference

How To Use This Cross Reference

1. Prior to the serial breaks listed, use an original Kohler adjustable jet carburetor when available from Distributor's stock.

   Where serial breaks are not listed, and the engine was built with an original Kohler adjustable jet carburetor, use an original Kohler adjustable jet carburetor.

2. If an original Kohler adjustable jet carburetor is no longer available, and the engine serial number is prior to the serial break, order the corresponding Walbro fixed or adjustable jet carburetor kit.

   If the engine serial number is at or after the serial break, determine the part number of the carburetor installed on the engine. *The part number is stamped on the carburetor mounting flange.)

3. Locate the carburetor part number (from step 2) in either the "Walbro Fixed Jet Car" column or "Walbro Adj Jet Carb" column. Use the corresponding carburetor kit.

4. If a Walbro fixed jet carburetor kit is no longer available from Kohler Co./Distributor stock, use the corresponding Walbro adjustable jet kit.

NOTE: Carburetors listed in the "Walbro Fixed Jet Carb" column and "Walbro Adj Jet Carb" column are for reference only. Always order the corresponding carburetor kit.

Carburetor kits include a carburetor assembly, gasket and/or linkage.

Engine Model	Original Kohler Adj. Carb.	Serial Break	Walbro Fixed Jet Carb. Kit*	Walbro Fixed Jet Carb.	Walbro Adj. Jet Carb. Kit*	Walbro Adj. Jet Carb.
K91						
	G-220517	2018300019	————	————	46 853 01	46 053 05
K161						
	41 053 13	1915100012	————	————	41 853 11	41 053 32
K181/M8						
	C-231738	————	41 853 01	41 053 21	41 853 06	41 053 28 41 053 34
	B-231739	1814800012	41 853 02	41 053 22	41 853 08	41 053 29
	41 053 01	1813100012	41 853 03	41 053 23	41 853 09	41 053 30
	41 053 13	1915000012	————	————	41 853 11	41 053 32
	41 053 18	1813300012	41 853 04	41 053 26 41 053 24	41 853 07	41 053 27
	41 053 20	1823000012	————	————	41 853 10	41 053 31
	————	————	————	————	41 853 12	41 053 36
K241-301,M10-12						
	47 053 07	1724400013	47 853 09	47 053 65	47 853 20	47 053 86
	47 053 08	1724400013	47 853 09	47 053 65	47 853 20	47 053 86
	47 053 12	1723800013	47 853 01	47 053 66	47 853 21	47 053 87
	47 053 13	1725405693	47 853 02	47 053 67	47 853 22	47 053 88
	47 053 14	1723900013	47 853 03	47 053 68	47 853 23	47 053 89
	47 053 24	1723900013	47 853 15	47 053 83	47 853 26	47 053 92
	47 053 29	1727100013	47 853 07	47 053 72	47 853 24	47 053 90
	47 053 40	1727207134	47 853 10	47 053 74	47 853 25	47 053 91
	47 053 62	1725300013	47 053 09	47 053 65	47 853 20	47 053 86
	47 053 80	1726700013	47 853 18	47 053 84	47 853 27	47 053 93
K321,M14						
	47 053 03	1733700013	47 853 08	47 053 64	47 853 29	47 053 96
	47 053 09	1733700013	47 853 08	47 053 64	47 853 29	47 053 96
	47 053 15	1735210504	47 853 04	47 053 69	47 853 30	77 053 07
	47 053 16	1733600013	47 853 05	47 053 70	47 853 31	47 053 98
	47 053 17	1733700013	47 853 16	47 053 71	47 853 32	47 053 99
	47 053 20	1733700013	47 853 06	47 053 71	47 853 32	47 053 99
	47 053 30	1733700013	47 853 17	47 053 82 77 053 05	47 853 35	77 053 03
	47 053 35	1725200013	47 853 19	47 053 85	47 853 28	47 053 94
	47 053 41	1812410383	47 853 11	47 053 75	47 853 33	77 053 06(KA) 77 053 01(WA)
	47 053 63	1734308964	47 853 08	47 053 64	47 853 29	47 053 96
	47 053 78	1733600013	47 853 14	47 053 79	47 853 34	77 053 02

***Includes carburetor, gasket, and/or linkage.**

Engine Model	Original Kohler Adj. Carb.	Serial Break	Walbro Fixed Jet Carb. Kit*	Walbro Fixed Jet Carb.	Walbro Adj. Jet Carb. Kit*	Walbro Adj. Jet Carb.
K341,M16						
	45 053 08	1806000013	45 853 05	45 053 75	45 853 12	45 053 88(KA) 45 053 83(WA)
	45 053 09	1802100013	45 853 05	45 053 75	45 853 12	45 053 88(KA) 45 053 83(WA)
	45 053 12	1805500013	45 853 02	45 053 71	45 853 08	45 053 79
	45 053 20	1809800013	45 853 01	45 053 72	45 853 09	45 053 87
	45 053 26	1802200013	45 853 06	45 053 73	45 853 10	45 053 81
	45 053 68	1812408663	45 853 04	45 053 74	45 853 11	45 053 86(KA) 45 053 82(WA)
	45 053 70	1802100013	45 853 05	45 053 75	45 853 12	45 053 88(KA) 45 053 83(WA)
	45 053 76	1808809063	45 853 07	45 053 78	45 853 13	45 053 84
	45 053 77	———	45 053 07	45 053 78	45 853 13 45 853 15 45 853 16	45 053 84 45 053 89 45 053 90
K582						
	48 053 06	———	———	———	———	———
KT17-19/M18-MV20						
KT17/M18	52 053 09	1630206306	52 853 07	52 053 26 52 053 31 52 053 36	52 853 23	52 053 50 52 053 66
KT17/M18	52 053 18	1629500996	25 853 04	52 053 27 52 053 32 52 053 34	52 853 30	52 053 51
KT17/M18	52 053 28	1720308366	52 853 21	52 053 37	52 853 24	52 053 52
M18	———	———	———	———	52 853 33	52 053 52
M18/M20	———	———	———	———	52 853 31	52 053 60
	———	———	———	———	52 853 32	52 053 69
KT19/M20	52 053 09	1919504216	52 853 01	52 053 20 52 053 46	52 853 27	52 053 58 52 053 63
KT19/M20	52 053 18	1919504216	52 853 02	52 053 21 52 053 47	52 853 28	52 053 59
M20	———	———	52 853 22	52 053 38	52 835 26	52 053 56
	———	———			52 853 34	52 053 56
MV16/MV18	———	———	52 853 09	52 053 34	52 853 25	52 053 54
	———	———	52 853 05	52 053 27	52 853 25	52 053 54
MV20	———	———	Not Available	52 053 21	52 853 29	52 053 55

***Includes carburetor, gasket, and/or linkage.**

Section 2
Carburetor Adjustment

Kohler engines are equipped with one of two basic types of carburetors – Kohler or Walbro – fixed main jet or adjustable main jet. This section covers the carburetor adjustment procedures for all Kohler engines.

Kohler carburetor adjustments are covered on pages **2.1 & 2.2**. Walbro carburetor adjustments are covered on pages **2.3 & 2.4**. Preliminary settings for both type carburetor is on page **2.5**.

The carburetor is designed to deliver the correct fuel-to-air mixture to the engine under all operating conditions. The main fuel and low idle fuel needles on adjustable jet carburetors are set at the factory and normally do not need further adjustment. On fixed jet carburetors, the low idle fuel needle is also set at the factory and normally does not need further adjustment. The main fuel jet is calibrated and installed at the factory and is not adjustable*.

*NOTE: Engines operating at altitudes above approximately 1830 m (6000 ft.) may require a special "high altitude" main jet.

Troubleshooting

If engine troubles are experienced that appear to be fuel system related, check the following areas before adjusting the carburetor.

- Make sure the fuel tank is filled with clean, fresh gasoline.
- Make sure the fuel tank cap vent is no blocked and that it is operating properly.
- Make sure fuel is reaching the carburetor. This includes checking the fuel shut-off valve, fuel tank filter screen, in-line fuel filter, fuel lines, and fuel pump for restrictions or faulty components as necessary.
- Make sure the air cleaner base and carburetor is securely fastened to the engine using gaskets in good condition.
- Make sure the air cleaner element is clean and all air cleaner components are fastened securely.
- Make sure the ignition system, governor system, exhaust system, and throttle and choke controls are operating properly.

If, after checking the items listed above, starting or engine operation problems exists, it may be necessary to adjust the carburetor.

NOTE: Carburetor adjustments should be made only after the engine has warmed up.

Kohler Carburetor Adjustment

In general, turning the adjusting needles in (clockwise) decreases the supply of fuel to the carburetor. This gives a leaner fuel-to-air mixture. Turning the adjusting needles out (counterclockwise) increases the supply of fuel to the carburetor. This gives a richer fuel-to-air mixture. Setting the needles midway between the lean and rich positions will usually give the best results.

Adjust the carburetor as follows:

1. With the engine stopped, turn the low idle fuel adjusting needle in (clockwise) until it bottoms lightly.

   NOTE: The tip of the low idle fuel and main fuel adjusting needles are tapered to critical dimensions. Damage to the needles and the seats in carburetor body will result if the needles are forced.

2. **Preliminary Settings:** Turn the adjusting needles out (counterclockwise) from lightly bottomed according to the table shown in Figure **2-5**.

3. Start the engine and run at half throttle for five to ten minutes to warm up. The engine must be warm before making final settings steps 4, 5, 6, and 7).

4. **Main Fuel Needle Setting:** This adjustment is required only for adjustable main jet carburetors. If the carburetor is a fixed main jet type, refer to Walbro adjustment.

   Place the throttle into the "fast" position. If possible, place the engine under lead.

   Turn the main fuel adjusting needle out (counterclockwise) from the preliminary setting until the engine speed decreases (rich). Note the position of the needle.

   Now turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned in (lean). Note the position of the needle.

   Set the adjusting needle midway between the rich and lean settings. See Figure **2-1**.

5. **Low Idle Speed Setting:** Place the throttle control into the "idle" or "slow" position. Set the low idle speed to 1200 RPM* (+ or – 75 RPM) by turning the low idle speed adjusting screw in or out. Check the speed using a tachometer.

   *NOTE: The actual low idle speed depends on the application. Refer to the equipment manufacturer's instructions for specific low idle speed settings. The recommended low idle speed for the Basic Engines is 1200 RPM. To ensure best results when setting the low idle fuel needle, the low idle speed must not exceed 1500 RPM.

6. **Low Idle Fuel Needle Setting:** Place the throttle into the "idle" or "slow" position.

   Turn the low idle fuel adjusting needle out (counterclockwise) from the preliminary setting until the engine speed decreases (rich). Note the position of the needle.

   Now turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned in (lean). Note the position of the needle.

   Set the adjusting needle midway between the rich and lean settings. See Figure **2-1**.

7. Recheck the low idle speed using a tachometer. Readjust the speed as necessary.

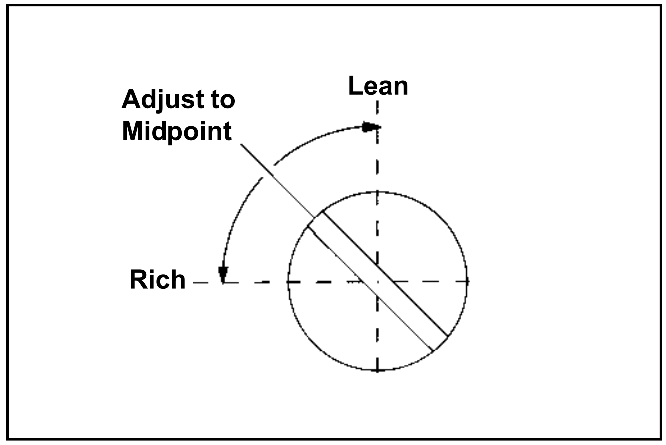


Figure 2-1. Optimum Low Idle Fuel Setting.

Walbro Carburetor Adjustment

In general, turning the adjusting needles in (clockwise) decreases the supply fuel to the carburetor. This gives a leaner fuel-to-air mixture. Turning the adjusting needles out (counterclockwise) increase the supply of fuel to the carburetor.

Adjust the carburetor as follows, see Figure **2-2** for needle locations.

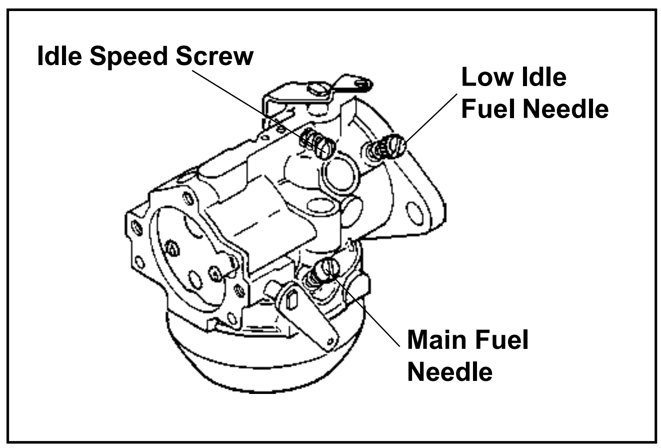


Figure 2-2. Adjusting Needle Locations.

NOTE: The tip of the low idle fuel and main fuel adjusting needles are tapered to critical dimensions. Damage to the needles and the seats in carburetor body will result if the needles are forced.

Refer to Figure **2-5** for preliminary settings.

1. With the engine stopped, turn the adjusting needle(s) in (clockwise) until it bottoms lightly.

2. **Preliminary Settings:** Turn the adjusting needle(s) out (counterclockwise) from lightly bottomed according to the table shown in Figure **2-5**, or to the rich side of adjustment.

3. Start the engine and run at half throttle for five to ten minutes to warm up. The engine must be warm before making final settings.

4. **Main Fuel Needle Setting:** This adjustment is required only for adjustable main jet carburetors. If the carburetor is a fixed main jet type, disregard this setting.

   Place the throttle into the “fast” position.

   Turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned in (lean). Note the position of the needle. Back the needle out approximately 1/8 to 1/4 turn. See Figure **2-3** for best main fuel performance.

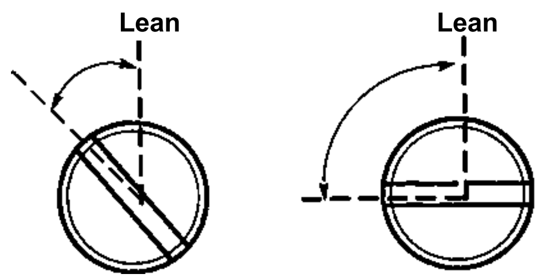


Figure 2-3. Optimum Mail Fuel Setting.

5. **Low Idle Speed Setting:** Place the throttle control into the “idle” or “slow” position. Set the low idle speed to 1200 RPM* (+ or – 75 RPM) by turning the low idle speed adjusting screw in or out. Check the speed using a tachometer.

   *NOTE: The actual low idle speed depends on the application. Refer to the equipment manufacturer’s instructions for specific low idle speed settings. To ensure best results when setting the low idle fuel needle, the low idle speed must not exceed 1500 RPM.

6. **Low Idle Fuel Needle Setting:** Place the throttle into the “idle” or “slow” position.

   Turn the adjusting needle in (clockwise). The engine speed may increase, then it will decrease as the needle is turned in (lean). Note the position of the needle.

   Back the needle out approximately 1/8 to 1/4 turn. See Figure **2-4** for best low idle fuel performance.

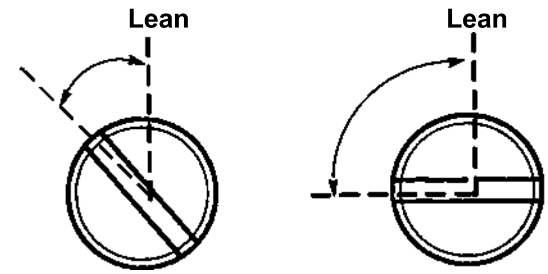


Figure 2-4. Optimum Low Idle Fuel Setting.

Preliminary Settings

K-Series Models

	Kohler Adjustable Jet		Walbro Fixed Jet	Walbro Adjustable Jet	
	Low Idle	**High Idle**	**Low Idle**	**Low Idle**	**Main Fuel**
K91	1-1/2 turns	2 turns	NOT APPL	1-3/4 turns	3/4 turn
K141	1-1/2 turns	3 turns	NOT APPL	NOT APPL	NOT APPL
K161*	1-1/2 turns	3 turns	NOT APPL	2-1/4 turns	1-1/8 turns
K181*	1-1/4 turns	2 turns	2-1/2 turns	2-1/2 turns	3/4 turn
K241	2-1/2 turns	2 turns	1-1/4 turns	1-3/4 turns	1-1/8 turns
K301	2-1/2 turns	2 turns	1-1/2 turns	1-3/4 turns	1-1/8 turns
K321	2-1/2 turns	3-1/4 turns	1-1/2 turns	1-1/8 turns	1-1/4 turns
K341	2-1/2 turns	3-1/2 turns	1 turn	2-1/2 turns	1-1/4 turns
KT17	1 turn	2-1/2 turns	1-1/4 turns	1-1/4 turns	1-1/4 turns
KT19	1 turn	2-1/2 turns	1-1/4 turns	1-1/4 turns	1 turn
K582	1-1/4 turns	3 turns	NOT APPL	2 B DETERMINED	2 B DETERMINED

*Includes "New Look" Models

Magnum Models

	Kohler Adjustable Jet		Walbro Fixed Jet	Walbro Adjustable Jet	
	Low Idle	**High Idle**	**Low Idle**	**Low Idle**	**Main Fuel**
M8	1-1/4 turns	2 turns	2-1/2 turns	2-1/2 turns	3/4 turn
M10	2-1/2 turns	2 turns	1-1/4 turns	1-3/4 turns	1-1/8 turns
M12	2-1/2 turns	2 turns	1-1/4 turns	1-3/4 turns	1-1/8 turns
M14	2-1/2 turns	3-1/4 turns	1-1/2 turns	1-1/8 turns	1-1/4 turns
M16	2-1/2 turns	3-1/2 turns	1 turn	2 turns	7/8 turn
M18	1 turn	2-1/2 turns	1-1/4 turns	1-1/4 turns	1-1/4 turns
M20	1 turn	2-1/2 turns	1-1/4 turns	1-1/4 turns	1 turn
MV16/18	NOT APPL	NOT APPL	1-1/4 turns	1-1/4 turns	1-1/4 turns
MV20	NOT APPL	NOT APPL	1-1/4 turns	1-1/4 turns	1 turn

Command Models

	Kohler Adjustable Jet		Walbro Fixed Jet	Walbro Adjustable Jet	
	Low Idle	**High Idle**	**Low Idle**	**Low Idle**	**Main Fuel**
C5	NOT APPL	NOT APPL	1 turn	NOT APPL	NOT APPL
CV12.5	NOT APPL	NOT APPL	1 turn	NOT APPL	NOT APPL

Figure 2-5.

Section 3
SERVICE PARTS LISTING

This section contains indexed illustrations and complete part number breakdowns for the Kohler adjustable and Walbro fixed/adjustable carburetors.

The Kohler carburetors are covered on pages **3.2 – 3.5**. 1/2” Walbro carburetors are covered on pages **3.6 – 3.7**. 1” Walbro carburetors are covered on pages **3.8 – 3.11**.

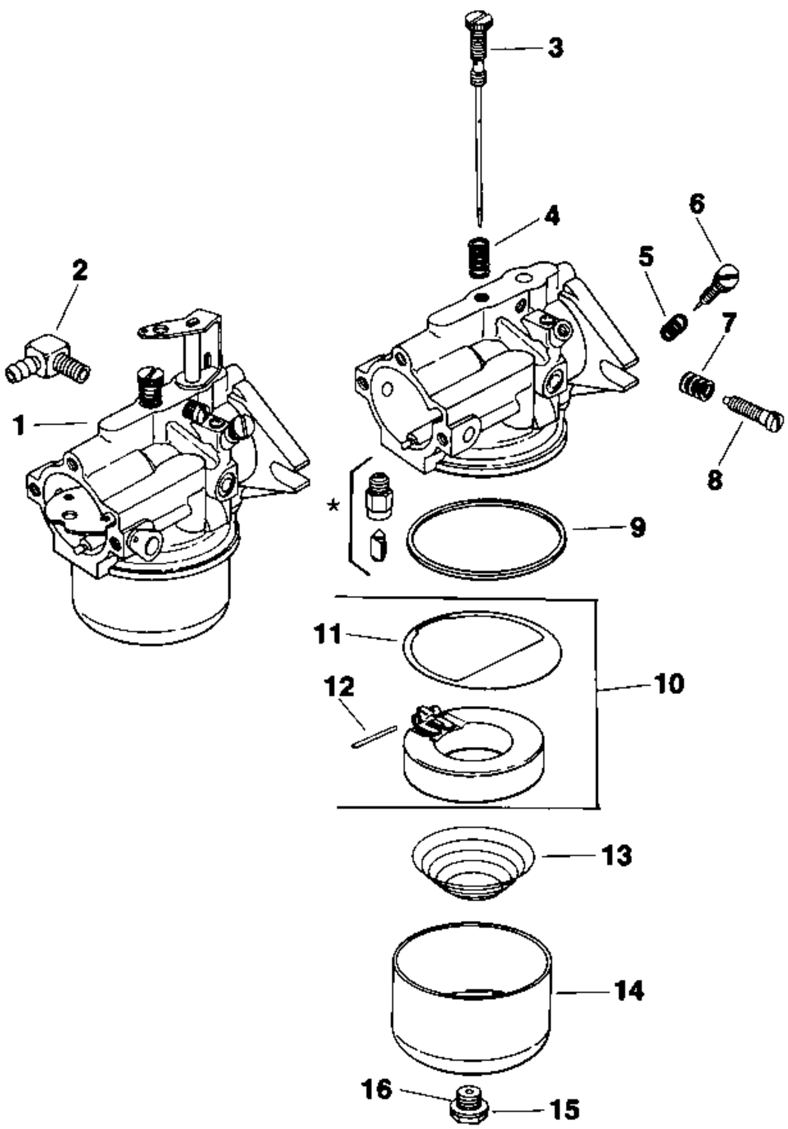
Here is a listing for quick reference of all fixed main jets and high altitude jet kits and jet size.

Fixed Main Jets

Kohler Part No.	Jet Size
45 337 01	0.051
47 337 02	0.045
52 337 01	0.047
52 337 03	0.050
52 337 04	0.052
52 337 06	0.055
52 337 07	0.048
52 337 08	0.046
52 337 09	0.060

High Altitude Jet Kits

Kohler Part No.	Jet Size
41 755 30	0.044
45 755 14	0.049
47 755 36	0.042
47 755 38	0.043
52 755 68	0.044
52 755 74	0.047
52 755 95	0.058
52 755 96	0.046
52 755 97	0.049
52 755 98	0.052



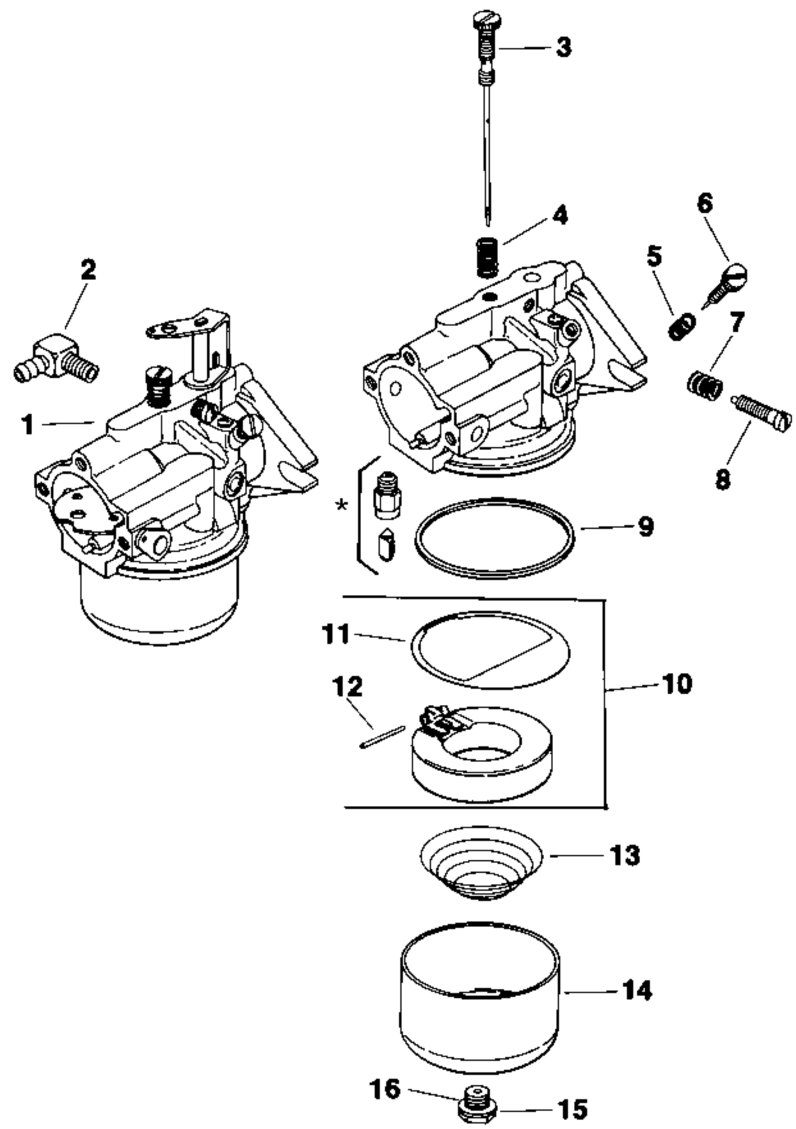
1/2" Kohler Adjustable Carburetor

Carburetor Part No.	Connector Hose	Needle, Hi Speed Adj	Spring, Hi Spd Needle	Spring, Idle Needle	Needle, Idle Adj.	Spring, Idle Screw	Screw, Idle Adj	Gasket Bowl	Float Kit
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**15**
G-220517	-	200410	200383	200380	200438	232555	232556	200375	25 757 03
C-231738	-	232635	200383	200380	200438	232555	232556	200375	25 757 03
B-231739	-	232635	200383	200380	200438	232555	232556	200375	25 757 03
41 053 01	X-391-9	232635	300383	200380	200438	232555	232556	200375	25 757 03
41 053 13	-	200410	200383	200380	200438	232555	232556	200375	25 757 03
41 053 18	-	232635	200383	200380	200438	232555	232556	200375	25 757 03
41 053 20	-	232635	200383	200380	200438	232555	232556	200375	25 757 03

1" Kohler Adjustable Carburetor

Carburetor Part No.	Connector Hose	Needle, Hi Speed Adj	Spring, Hi Spd Needle	Spring, Idle Needle	Needle, Idle Adj.	Spring, Idle Screw	Screw, Idle Adj	Gasket Bowl	Float Kit
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**25**
45 053 06	-	48 103 01	200383	200380	277210	200380	234945	200375	25 757 03

***Included in Carburetor Repair Kit**



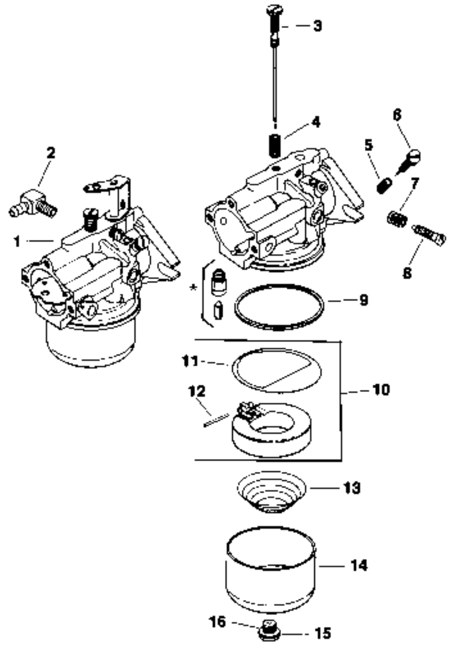
1/2" Kohler Adjustable Carburetor

Gasket, Bowl Baffle	Pin, Float	Spring, Float	Bowl, Fuel	Screw, Bowl Retainer	Gasket, Bowl ret. Screw	Repair Kit	Shaft Repl Kit	Carburetor Part No.
11	**12**	**13**	**14**	**15**	**16**			**1**
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	G-220517
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	C-231738
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	B-231739
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	41 053 01
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	41 053 13
25 041 02	200376	-	200418	41 100 01	200372	25 757 01	25 757 04	41 053 18
25 041 02	200376	237917	200418	41 100 01	200372	25 757 01	25 757 04	41 053 20

1/2" Kohler Adjustable Carburetor

Gasket, Bowl Baffle	Pin, Float	Spring, Float	Bowl, Fuel	Screw, Bowl Retainer	Gasket, Bowl ret. Screw	Repair Kit	Shaft Repl Kit	Swivel Clamp Kit	Carburetor Part No.
11	**12**	**13**	**14**	**15**	**16**				**1**
25 041 02	200376	-	235448	47 100 06	200372	25 757 02	-	48 755 10	48 053 06

***Included in Carburetor Repair Kit**



1" Kohler Adjustable Carburetor

Carburetor Part No.	Connector Hose	Needle, Hi Speed Adj	Spring, Hi-Speed	Spring Idle Needle	Needle Idle Adj	Spring Idle	Screw Idle Adj	Gasket, Bowl	Float Kit
1	2	3	4	5	6	7	8	9	10
45 053 08		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 09		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 12		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 20		45 103 01	200383	200380	272531	232555	232556	200375	25 757 03
45 053 26	X-391-10	45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 68		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 70		45 103 01	200383	200380	275231	232556	232556	200375	25 757 03
45 053 76	X-391-10	45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 77	X-391-10	45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 86		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 87		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 88		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 89		45 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 03		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
45 053 07		235415	200383	200380	235006	232555	232556	200375	25 757 03
45 053 08		235415	200383	200380	235006	232555	232556	200375	25 757 03
45 053 09		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 12		235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 13		235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 14		235415	200383	200380	235006	232555	232556	230075	25 757 03
47 053 15		47 103 01	200383	200380	275231	232555	232556	230075	25 757 03
47 053 16		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 17		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 20	X-391-10	47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 24		235415	200383	200380	235006	232555	232556	230075	25 757 03
47 053 29	X-391-10	235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 30		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 35		235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 40		235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 41		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 62		235415	200383	200380	235006	232555	232556	200375	25 757 03
47 053 63		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 78	X-391-10	47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
47 053 80	X-391-10	235415	200383	200380	235006	232555	232556	200375	25 757 03
52 053 09		52 103 01	200383	200380	277210	232555	232556	200375	25 757 03
52 053 18		52 103 01	200383	200380	277210	232555	232556	200375	25 757 03
52 053 28		52 103 01	200383	200380	277210	232555	232556	200375	25 757 03
52 053 60	25 155 02	52 103 01	200383	200380	235006	232555	232556	200375	25 757 03
77 053 06		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03
77 053 07		47 103 01	200383	200380	275231	232555	232556	200375	25 757 03

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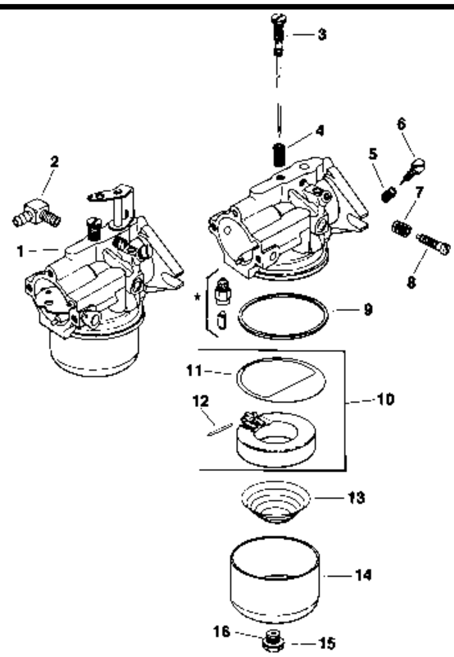

1" Kohler Adjustable Carburetor

Gasket, Bowl Baffle	Pin Float	Spring, Float	Bowl, Fuel	Screw, Bowl Ret.	Gasket Bowl Ret.	Repair Kit	Shaft Repl. Kit	Solenoid Kit	Carburetor Part No.
11	12	13	14	15	16				
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		45 053 08
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 09
25 041 02	200376	237917	235448	47 100 06	200372	25 757 02	25 757 05		45 053 12
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 20
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 26
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 68
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 70
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 76
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 77
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 86
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 083 87
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		45 053 88
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 12		45 053 89
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 03
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 07
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		47 053 08
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		47 053 09
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 12
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 13
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 14
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 15
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 16
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 17
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 20
25 041 02	200376	237917	235448	47 100 06	200372	25 757 02	25 757 05		47 053 24
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 29
25 041 02	200376	237917	235448	47 100 06	200372	25 757 02	25 757 05		47 053 30
25 041 02	200376	237917	235448	47 100 06	200372	25 757 02	25 757 05		47 053 35
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 40
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 41
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 62
25 041 02	200376		235448	47 100 02	200372	25 757 01	25 757 05		47 053 63
25 041 02	200376	237917	235448	47 100 06	200372	25 757 01	25 757 05		47 053 78
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		47 053 80
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		52 053 09
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05		52 053 18
25 041 02	200376		235448	47 100 06	200372	25 757 02	25 757 05	25 755 05	52 053 28
25 041 02	200376		235448	47 100 06	200372	25 757 02		25 755 05	52 053 60
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		77 053 06
25 041 02	200376		235448	47 100 06	200372	25 757 01	25 757 05		77 053 07

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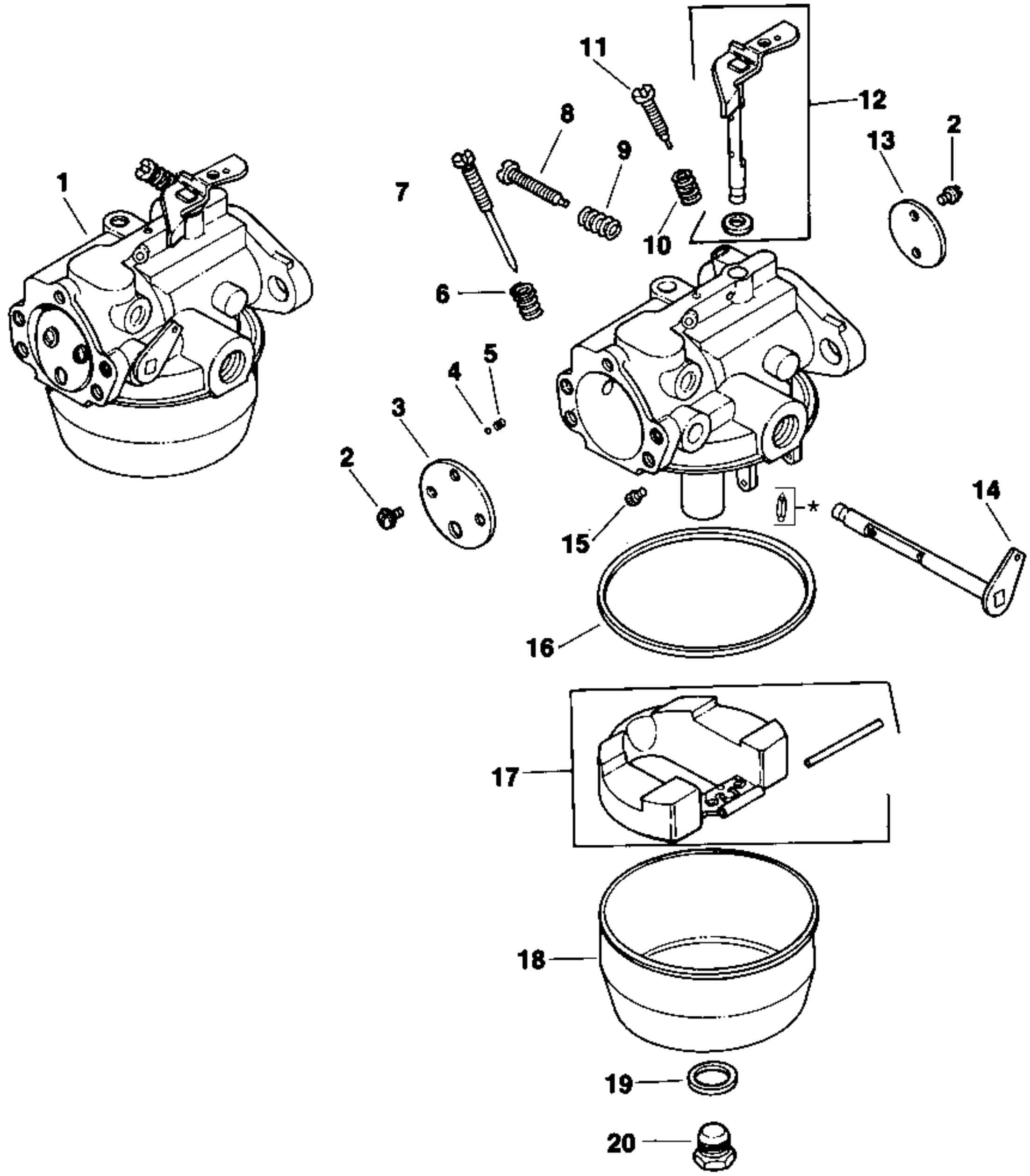

1/2" Walbro Fixed/Adjustable Carburetor

Carb Part No.	Screw, Thr.& Ch. Plate	Plate, Choke	Ball, Choke	Spring, Choke	Spring Main Needle	Needle Hi-Speed	Screw Throttle Adj.	Spring Throttle Adj.	Spring Idle Needle	Needle Idle Adj.	Thr. Shaft W/Seal
1	2	3	4	5	6	7	8	9	10	11	12
41 053 21	25 086 27	41 146 16	25 194 02	25 089 06			25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 22	25 086 27	41 146 16	25 194 02	25 089 06			25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 23	25 086 27	41 146 16	25 194 02	25 089 06			25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 24	25 086 27	41 146 16	25 194 02	25 089 06			25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 26	25 086 27	41 146 16	25 194 02	25 089 06			25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 27	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 28	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 29	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 30	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 31	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 32	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 34	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
41 053 36	25 086 27	41 146 16	25 194 02	25 089 06	25 089 02	25 368 04	25 086 26	25 089 04	25 089 02	25 368 02	41 144 18
46 053 05	25 086 27	46 146 03	25 194 02	25 089 06	25 089 02	25 368 03	25 086 26	25 089 04	25 089 02	25 368 02	46 144 04

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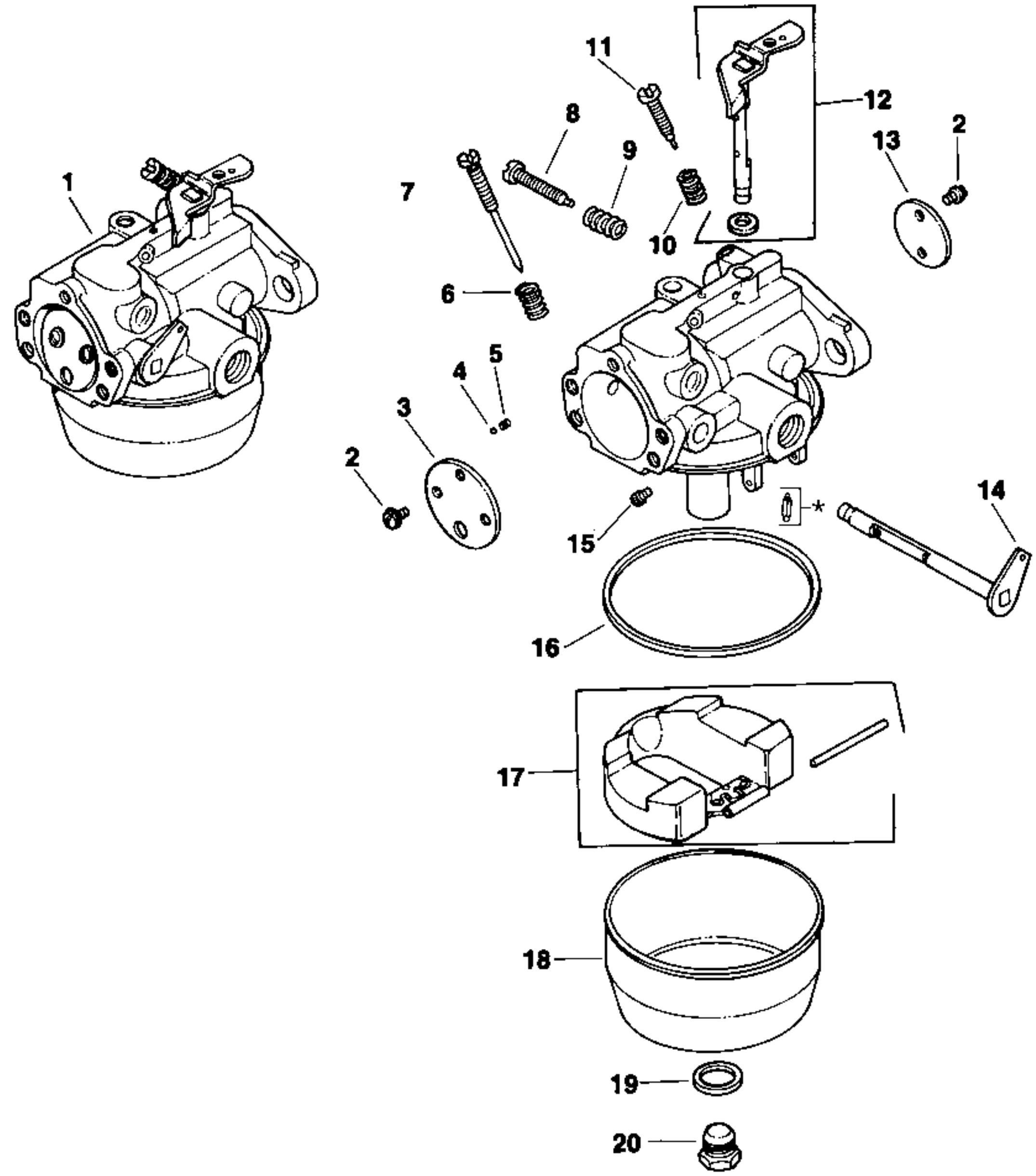

1/2" Walbro Fixed/Adjustable Carburetor

Plate, Throttle	Shaft, Choke	Jet, Main	Gasket, Bowl	Float Kit	Bowl Fuel	Gasket, Bowl Retl Screw	Screw, Bow Retainer	Repair Kit	Hi-Alt Jet Kit	Carb. Part No.
13	**14**	**15**	**16**	**17**	**18**	**19**	**20**			**1**
25 146 05	41 090 20	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11	41 755 30	41 053 21
25 146 05	41 090 21	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11	41 755 30	41 053 22
25 146 05	41 090 20	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11	41 755 30	41 053 23
25 146 05	41 090 22	52 337 08	52 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11	41 755 30	41 053 26
25 146 05	41 090 22	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11	41 755 30	41 053 26
25 146 05	41 090 22		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 27
25 146 05	41 090 20		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 28
25 146 05	41 090 21		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 29
25 146 05	41 090 20		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 30
25 146 05	41 090 22		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 31
25 146 05	41 090 20		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 32
25 146 05	41 090 20		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 34
25 146 05	41 090 22		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		41 053 36
25 146 05	41 090 20		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		46 053 05

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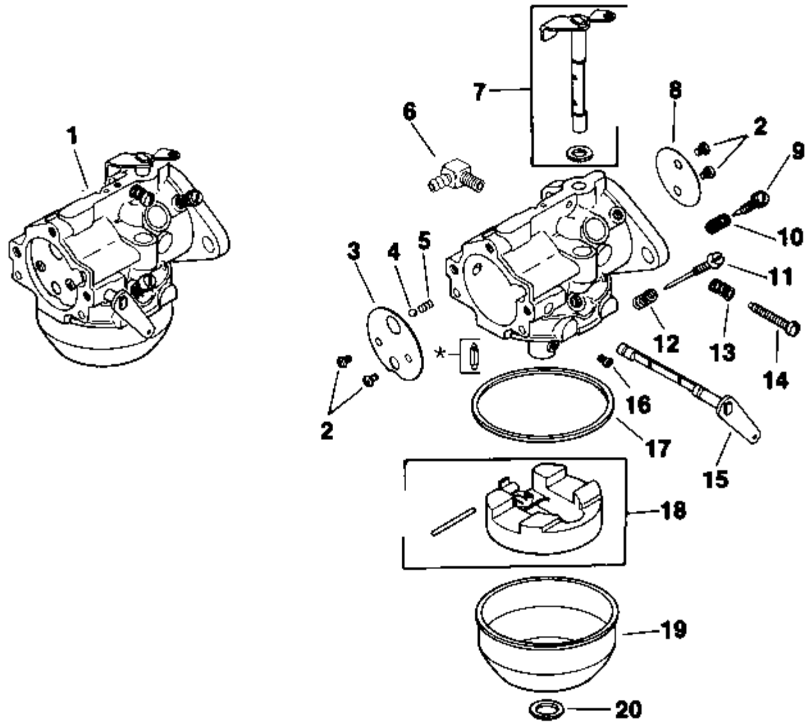

1" Walbro Fixed/Adjustable Carburetor

Carb Part No.	Screw Thr. & Ch. Plate	Plate, Choke	Ball, Choke	Spring, Choke	Fitting, Breather	Thr. Shaft W/Seal	Plate, Throttle	Needle, Idle Adj.	Speed, Idle Needle	Needle High, Speed	Spring, Main Needle	Spring, Thr. Adj.
1	2	3	4	5	6	7	8	9	10	11	12	13
45 053 71	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 72	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 73	25 086 27	45 146 07	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 74	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 75	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 78	25 086 27	45 146 07	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
45 053 79	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
45 053 81	25 086 27	45 146 07	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
45 053 82	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
45 053 83	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
45 053 84	25 086 27	45 146 07	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
45 053 90	25 086 27	45 146 07	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 64	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 65	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02			25 089 04
47 053 66	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 03			25 089 04
47 053 67	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02			25 089 04
45 053 68	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 03			25 089 04
47 053 69	25 086 27	47 146 08	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 70	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 71	25 086 27	47 146 09	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 72	25 086 27	47 146 08	25 194 01	25 089 03	25 155 05	47 144 21	25 146 02	25 368 01	25 089 03			25 089 04
47 053 74	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 03			25 089 04
47 053 75	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 79	25 086 27	47 146 08	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 81	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 82	25 086 27	47 146 09	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02			25 089 04
47 053 83	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02			25 089 04
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47 053 86	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 87	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 88	25 086 27	47 146 08	25 194 01	28 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 89	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 90	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 91	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04

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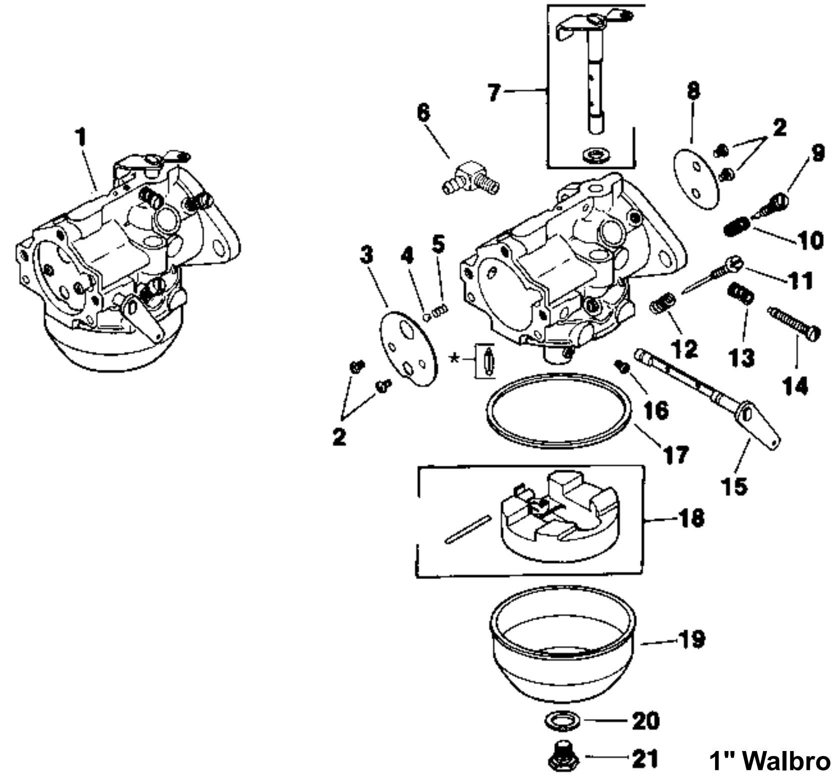

1" Walbro Fixed/Adjustable Carburetor

Screw, Thr. Adj.	Shaft, Choke	Jet, main	Gasket, Bowl	Float Kit	Bowl, Fuel	Gasket, Bowl Ret. Screw	Screw, Bowl Retainer	Repair Kit	Hi-Alt Jet Kit	Solenoid Kit	Carb. Part No.
14	15	16	17	18	19	20	21				1
25 086 26	47 090 38	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 71
25 086 26	47 090 34	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 72
25 086 26	47 090 35	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 73
25 086 26	47 090 37	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 74
25 086 26	47 090 38	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 75
25 086 26	47 090 38	45 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		45 053 78
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 79
25 086 26	47 090 35		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 81
25 086 26	47 090 37		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 82
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 83
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 84
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03		25 757 11		52 435 06	45 083 90
25 086 26	47 090 38	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 64
25 086 26	47 090 38	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 14		47 053 65
25 086 26	47 090 35	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 66
25 086 26	47 090 34	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 67
25 086 26	47 090 35	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 68
25 086 26	47 090 34	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 69
25 086 26	47 090 36	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 70
25 086 26	47 090 38	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 71
25 086 26	47 090 35	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 72
25 086 26	47 090 37	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 74
25 086 26	47 090 37	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 75
25 086 26	47 090 38	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 79
25 086 26	47 090 35	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 81
25 086 26	47 090 38	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 38		47 053 82
25 086 26	47 090 38	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 83
25 086 26	47 090 38	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 84
25 086 26	47 090 35	47 337 02	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	47 755 36		47 053 85
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 86
25 086 26	47 090 35		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 87
25 086 26	47 090 34		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 88
25 086 26	47 090 35		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 89
25 086 06	47 090 35		25 041 05	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 90
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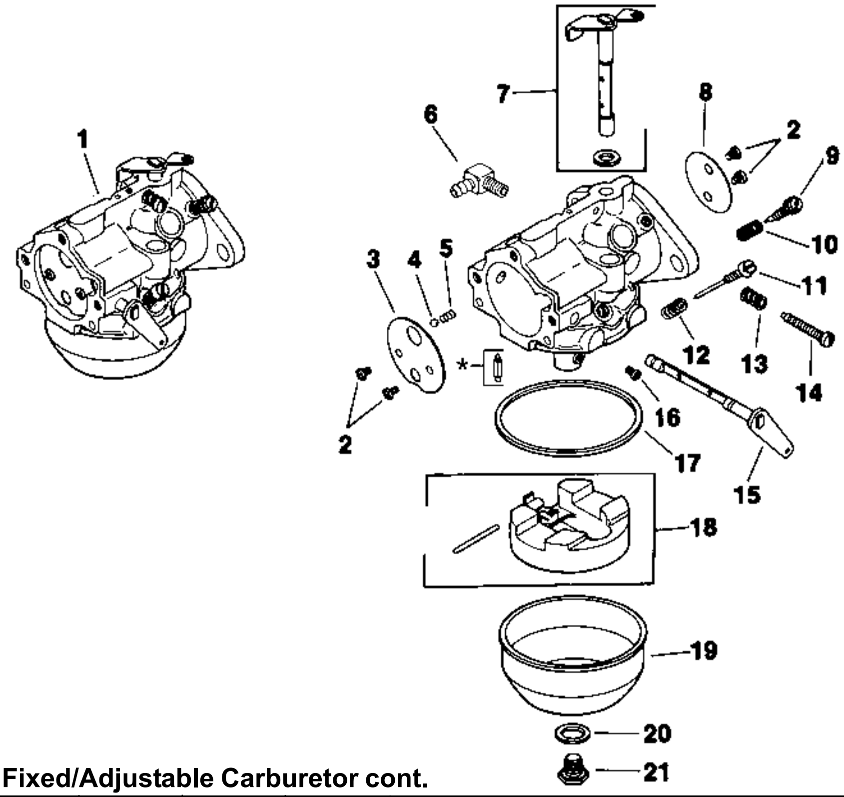
***Included in Carburetor Repair Kit**



1" Walbro Fixed/Adjustable Carburetor cont.

Carb Part No.	Screw, Thr. & Ch. Plate	Plate, Choke	Ball, Choke	Spring, Choke	Fitting Breather	Thr. Shaft W/Seal	Plate, Throttle	Needle, Idle Adj.	Spring, Idle Needle	Needle, Hi-Speed	Spring, Main Needle	Spring, Thr. Adj.
1	2	3	4	5	6	7	8	9	10	11	12	13
47 053 92	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 93	25 086 27	47 146 08	25 194 01	25 089 03		47 144 21	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
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47 053 98	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
47 053 99	25 086 27	47 146 09	25 194 01	25 089 03	25 155 05	47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 20	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 146 02	25 368 01	25 089 02			25 089 04
52 053 21	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 146 02	25 368 01	25 089 02			25 089 04
52 053 26	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 144 02	25 368 01	25 089 02			25 089 04
52 053 27	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 146 02	25 368 01	25 089 02			25 089 04
52 053 31	25 086 27	25 146 03	25 194 01	25 089 03		25 144 18	25 146 02	25 368 01	25 089 02			25 089 04
52 053 32	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02			25 089 04
52 053 34	25 086 27	25 146 03	25 194 01	25 089 03		25 144 16	25 146 02	25 368 01	25 089 02			25 089 04
52 053 36	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 146 02	25 368 01	25 089 02			25 089 04
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52 053 38	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02			25 089 04
52 053 46	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02			25 089 04
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52 053 51	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 52	25 083 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 54	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 55	25 086 27	25 146 03	25 194 01	25 089 03		52 144 16	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
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52 053 59	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 63	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
52 053 66	25 086 27	25 146 03	25 194 01	25 089 03		52 144 18	25 146 02	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
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77 053 01	25 086 27	47 146 09	25 194 01	25 089 03		47 144 25	47 146 10	25 368 01	25 089 02	25 368 03	25 089 02	25 089 04
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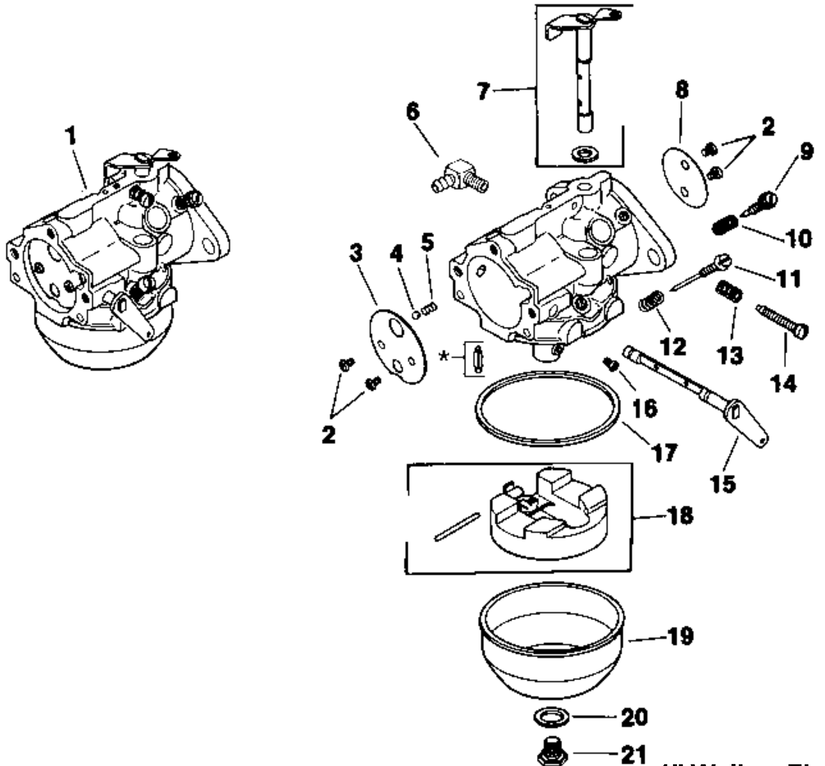
***Included in Carburetor Repair Kit**



1" Walbro Fixed/Adjustable Carburetor cont.

Screw, Thr. Adj.	Shaft, Choke	Jet, Main	Gasket, Bowl	Float Kit	Bowk Fuel	Gasket, Bowl Ret. Screw	Screw, Bowl Retainer	Repair Kit	Hi-Alt Jet Kit	Solenoid Kit	Carb. Part No.
14	15	16	17	18	19	20	21				1
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 92
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			47 053 93
25 086 26	47 090 35		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			45 053 94
25 086 26	47 090 38		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			47 053 96
25 086 26	47 090 36		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			47 053 98
25 086 26	47 090 34		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			47 053 99
25 086 26	52 090 12	52 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 68		52 053 20
25 086 26	52 090 13	52 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 68		52 053 21
25 086 26	52 090 12	52 337 03	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 74		52 053 26
25 086 26	52 090 13	52 337 03	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 74		52 053 27
25 086 26	52 090 12	52 337 06	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 98		52 053 31
25 086 26	52 090 13	52 337 06	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 98		52 053 32
25 086 26	52 090 13	52 337 06	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 98		52 053 34
25 086 26	52 090 12	52 337 06	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 98		52 053 36
25 086 26	52 090 12	25 337 09	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 98	25 755 06	52 053 37
25 086 26	52 090 12	52 337 07	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 96	25 775 06	52 053 38
25 086 26	52 090 12	52 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 68		52 053 46
25 086 26	52 090 13	52 337 01	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	52 755 68		52 053 47
25 086 26	52 090 12		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			52 053 50
25 086 26	52 090 13		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			52 053 51
25 086 26	52 090 12		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		25 755 096	52 053 52
25 086 26	52 090 13		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			52 053 54
25 086 26	52 090 13		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			52 053 55
25 086 26	52 090 12		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11		25 757 06	52 053 56
25 086 26	52 090 12		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08			52 053 58
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25 086 26	52 090 12		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			52 053 66
	52 144 20		25 041 04	25 757 09	25 104 01	25 041 03		52 757 04		52 435 06	52 053 69
25 086 26	47 090 37		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			77 053 01
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25 086 26	47 090 35		25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 11			77 053 04
25 086 26	47 090 38	52 337 08	25 041 04	25 757 09	25 104 01	25 041 03	25 100 05	25 757 08	45 755 38		77 053 05

***Included in Carburetor Repair Kit**

POLICY AND PROCEDURE

KOHLER engines

Contents

Section 1 – Introduction

A. The Warranty Decision
Warranty decisions must be based on careful examination of the facts and circumstances surrounding the warranty request. The warranty covers defects in material or workmanship, so you must try to decide if the failure resulted from a manufacturing defect and is eligible for warranty consideration. If you feel that a decision will be difficult, or the customer is disputing your decision, complete an Engine Inspection Data Record (TP-2435), as shown on pages 14-16, and follow a systematic analysis procedure.

1. Complete the Owner's Information portion of the Engine Inspection Data Record when the customer brings the unit in for consideration.

2. Inspect the unit as delivered and complete the Air Filter Assembly, Crankcase Oil, Engine Cooling System, and Governor sections of the Engine Inspection Data Record.

   NOTE: Experience has shown that the information gained from these sections frequently will lead to the cause of the failure, and will determine what corrective action must be performed to prevent repeat failures.

3. Carefully disassemble the engine and check components for any unusual markings or wear patterns.

4. Take the necessary measurements and enter them in the proper sections in the Engine Inspection Data Record. Compare the measurements against published specifications in Kohler service literature to identify parts that may require rework or replacement.

If your analysis points to a deficiency in engine care or maintenance, recommend to your customer the preventive measures that must be performed to prevent repeat failures.

If there is a question whether the repair is covered by the Kohler Limited Engine Warranty, contact your Kohler Distributor to assist you in the analysis and warranty decision.

If, after reviewing the matter with the Kohler Distributor representative, a warranty decision still cannot be made, have the representative follow the ''chain of command'' until a decision is reached. Remember, **always** keep the customer advised as to what is being done, and why. This will show the customer full consideration is being extended and will demonstrate our mutual concern.

B. Pre-Sale Disclosure Requirement
One of the provisions of the Magnusson-Moss Consumer Products Warranties Law is that a retail seller of consumer products must make the text of the warranty available for review by the prospective buyer prior to sale. To help you comply with this law, the warranty statements for each model series are printed at the back of the owner's manual for that series. All of the warranty statements are included in Section 2 of this booklet.

C. Warranty Responsibility Begins Before Delivery
Each Kohler Service Account is responsible for preventing new engines (and parts) from deteriorating in storage, and also for preparing new engines for delivery. Failure to adequately protect and store engines and parts will result in unnecessary expense to the dealer, and will inconvenience and annoy customers. Successful service accounts have proven that the minimal investment involved in preparing an engine prior to delivery eliminates unnecessary service calls and results in improved over-all profit. Before turning an engine over, review the Owner's Manual with the customer–stress the importance of good maintenance and explain the warranty.

Section 2 – Limited Warranty Statements

Kohler Aegis™ Warranty Statement

Limited 3 Year Koher Aegis™ Engine Warranty

We warrant to the original consumer that each new KOHLER AEGIS™ engine sold by us will be free from manufacturing defects in materials or workmanship in normal service for a period of three (3) years from date of purchase, provided if is operated and maintained in accordance with Kohler Co.'s instructions and manuals.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us of such parts as inspection shall disclose to have been defective.

EXCLUSIONS:
Mufflers on engines used commercially (non-residential) are warranted for one (1) year from date of purchase, except catalytic mufflers, which are warranted for two (2) years.

This warranty does not apply to defects caused by casualty or unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty:

Engine accessories such as fuel tanks, clutches, transmissions, power-drive assemblies, and batteries, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

WE SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to labor costs or transportation charges in connection with the repair or replacement of defective parts.

ANY IMPLIED OR STATUARY WARRANTIES, INCLUDING WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is any one authorized to make any in our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

TO OBTAIN WARRANTY SERVICE:
Purchaser must bring the engine to an authorized Kohler service facility. For the facility nearest you, consult your Yellow Pages or write Kohler Co., Attn: Engine Warranty Service Dept., Kohler, Wisconsin, 53044.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

Command/Magnum/OHC/Courage Warranty Statement

Limited 2 Year Command/Magnum/OHC/Courage Engine Warranty

We warrant to the original consumer that each new Command/Magnum/OHC/Courage engine sold by us will be free from manufacturing defects in materials or workmanship in normal service for a period of two (2) years from date of purchase, provided it is operated and maintained in accordance with Kohler Co.'s instructions and manuals.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us, of such part or parts as inspection shall disclose to have been defective.

EXCLUSIONS:
Mufflers on engines used commercially (non-residential) are warranted for one (1) year from date of purchase, except catalytic mufflers, which are warranted for two (2) years.

This warranty does not apply to defects caused by casualty or unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty.

Engine accessories, such as fuel tanks, clutches, transmissions, power drive assemblies, and batteries, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

WE SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to labor costs or transportation charges in connection with the replacement or repair of defective parts.

ANY IMPLIED OR STATUTORY WARRANTIES, INCLUDING WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is anyone authorized to make any in our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

TO OBTAIN WARRANTY SERVICE:
Purchaser must bring the engine to an authorized Kohler service facility. For the facility nearest you, consult your Yellow Pages under ''Engines-Gasoline'' or phone 1-800-544-2444.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

K-Series Warranty Statement

Limited 1 Year Engine Warranty

We warrant to the original consumer that each new engine sold by us will be free from manufacturing defects in materials or workmanship in normal service for a period of one (1) year from date of purchase, provided it is operated and maintained in accordance with Kohler Co.'s instructions and manuals.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us, of such part or parts as inspection shall disclose to have been defective.

EXCLUSIONS:
Mufflers on engines used commercially (non-residential) are warranted for one (1) year from date of purchase, except catalytic mufflers, which are warranted for two (2) years.

This warranty does not apply to defects caused by casualty or unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty:

Engine accessories, such as fuel tanks, clutches, transmissions, power drive assemblies, and batteries, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

WE SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to labor costs or transportation charges in connection with the replacement or repair of defective parts.

ANY IMPLIED OR STATUTORY WARRANTIES, INCLUDING WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is anyone authorized to make any in our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

TO OBTAIN WARRANTY SERVICE:
Purchaser must bring the engine to an authorized Kohler service facility. For the facility nearest you, consult your Yellow Pages under ''Engines-Gasoline'' or phone 1-800-544-2444.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

Service Parts Warranty

Limited 90 Day Service Parts Warranty

We warrant to the original consumer that each new service part sold by us will be free from manufacturing defects in materials or workmanship in normal service for a period of 90 days from date of purchase, provided it is installed properly and the engine maintained in accordance with Kohler Co.'s instructions and manuals.

Our obligation under this warranty is expressly limited, at our option, to the replacement or repair at Kohler Co., Kohler, Wisconsin 53044, or at a service facility designated by us, of such part or parts as inspection shall disclose to have been defective.

EXCLUSIONS:
This warranty does not apply to defects caused by casualty or unreasonable use, including faulty repairs by others and failure to provide reasonable and necessary maintenance.

The following items are not covered by this warranty:

Engine accessories, unless supplied or installed by Kohler Co. These are subject to the warranties, if any, of their manufacturers.

WE SHALL NOT BE LIABLE FOR SPECIAL, INDIRECT, INCIDENTAL, OR CONSEQUENTIAL DAMAGES OF ANY KIND, including but not limited to, labor costs or transportation charges in connection with the replacement or repair of defective parts.

ANY IMPLIED OR STATUTORY WARRANTIES, INCLUDING WARRANTY OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE, ARE EXPRESSLY LIMITED TO THE DURATION OF THIS WRITTEN WARRANTY. We make no other express warranty, nor is anyone authorized to make any in our behalf.

Some states do not allow limitations on how long an implied warranty lasts, or the exclusion or limitation of incidental or consequential damages, so the above limitation or exclusion may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from state to state.

TO OBTAIN WARRANTY SERVICE:
Purchaser must bring the service parts to an authorized Kohler service facility. For the facility nearest you, consult your Yellow Pages under ''Engines-Gasoline'' or phone 1-800-544-2444.

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

KOHLER CO.
FEDERAL AND CALIFORNIA EMISSION CONTROL SYSTEMS LIMITED WARRANTY SMALL OFF-ROAD ENGINES

The U.S. Environmental Protection Agency (EPA), the California Air Resources Board (CARB), and Kohler Co. are pleased to explain the Federal and California Emission Control Systems Warranty on your small off-road equipment engine. For California, engines produced in 1995 and later must be designed, built and equipped to meet the state's stringent anti-smog standards. In other states, 1997 and later model year engines must be designed, built and equipped, to meet the U.S. EPA regulations for small non-road engines. The engine must be free from defects in materials and workmanship which cause it to fail to conform with U.S. EPA standards for the first two years of engine use from the date of sale to the ultimate purchaser. Kohler Co. must warrant the emission control system on the engine for the period of time listed above, provided there has been no abuse, neglect or improper maintenance.

The emission control system may include parts such as the carburetor or fuel injection system, the ignition system, and catalytic converter. Also included are the hoses, belts and connectors and other emission related assemblies.

Where a warrantable condition exists, Kohler Co. will repair the engine at no cost, including diagnosis (if the diagnostic work is performed at an authorized dealer), parts and labor.

MANUFACTURER'S WARRANTY COVERAGE
Engines produced in 1995 or later are warranted for two years in California. In other states, 1997 and later model year engines are warranted for two years. If any emission related part on the engine is defective, the part will be repaired or replaced by Kohler Co. free of charge.

OWNER'S WARRANTY RESPONSIBILITIES

(a) The engine owner is responsible for the performance of the required maintenance listed in the owner's manual. Kohler Co. recommends that you retain all receipts covering maintenance on the engine, But Kohler Co. cannot deny warranty solely for the lack of receipts or for your failure to assure that all scheduled maintenance was performed.

(b) Be aware, however, that Kohler Co. may deny warranty coverage if the engine or a part has failed due to abuse, neglect, improper maintenance or unapproved modifications.

(c) For warranty repairs, the engine must be presented to a Kohler Co. service center as soon as a problem exists. Call 1-800-544-2444 or access our web site at: www.kohlerengines.com, for the names of the nearest service centers. The warranty repairs should be completed in a reasonable amount of time, not to exceed 30 days.

If you have any questions regarding warranty rights and responsibilities, you should contact Kohler Co. at 1-920-457-4441 and ask for an Engine Service representative.

COVERAGE
Kohler Co. warrants to the ultimate purchaser and each subsequent purchaser that the engine will be designed, built and equipped, at the time of sale, to meet all applicable regulations. Kohler Co. also warrants to the initial purchaser and each subsequent purchaser, that the engine is free from defects in materials and workmanship which cause the engine to fail to conform with applicable regulations for a period of two years.

Engines produced in 1995 or later are warranted for two years in California. For 1997 and later model years, EPA requires manufacturers to warrant engines for two years in all other states. These warranty periods will begin on the date the engine is purchased by the initial purchaser. If any emission related part on the engine is defective, the part will be replaced by Kohler Co. at no cost to the owner. Kohler Co. is liable for damages to other engine components caused by the failure of a warranted part still under warranty.

Kohler Co. shall remedy warranty defects at any authorized Kohler Co. engine dealer or warranty station. Warranty repair work done at an authorized dealer or warranty station shall be free of charge to the owner if such work determines that a warranted part is defective.

Listed below are the parts covered by the Federal and California Emission Control Systems Warranty. Some parts listed below may require scheduled maintenance and are warranted up to the first scheduled replacement point for that part. The warranted parts are:

- Oxygen sensor (if equipped)
- Intake manifold (if equipped)
- Exhaust manifold (if equipped)
- Catalytic muffler (if equipped)
- Fuel metering valve (if equipped)
- Spark advance module (if equipped)
- Crankcase breather
- Ignition module(s) with high tension lead
- Gaseous fuel regulator (if equipped)
- Electronic control unit (if equipped)
- Carburetor or fuel injection system
- Fuel lines (if equipped)
- Air filter, fuel filter, and spark plugs (only to first scheduled replacement point)

LIMITATIONS
This Emission Control Systems Warranty shall not cover any of the following:

(a) repair or replacement required because of misuse or neglect, improper maintenance, repairs improperly performed or replacements not conforming to Kohler Co. specifications that adversely affect performance and/or durability and alterations or modifications not recommended or approved in writing by Kohler Co.,

(b) replacement of parts and other services and adjustments necessary for required maintenance at and after the first scheduled replacement point,

(c) consequential damages such as loss of time, inconvenience, loss of use of the engine or equipment, etc.,

(d) diagnosis and inspection fees that do not result in eligible warranty service being performed, and

(e) any add-on or modified part, or malfunction of authorized parts due to the use of add-on or modified parts.

MAINTENANCE AND REPAIR REQUIREMENTS
The owner is responsible for the proper use and maintenance of the engine. Kohler Co. recommends that all receipts and records covering the performance of regular maintenance be retained in case questions arise. If the engine is resold during the warranty period, the maintenance records should be transferred to each subsequent owner. Kohler Co. reserves the right to deny warranty coverage if the engine has not been properly maintained; however, Kohler Co. may not deny warranty repairs solely because of the lack of repair maintenance or failure to keep maintenance records.

Normal maintenance, replacement or repair of emission control devices and systems may be performed by any repair establishment or individual; however, **warranty repairs must be performed by a Kohler authorized service center**. Any replacement part or service that is equivalent in performance and durability may be used in non-warranty maintenance or repairs, and shall not reduce the warranty obligations of the engine manufacturer.

Section 3 – Warranty Procedures

A. Service Information Record

KOHLER engines BORN TO RUN

Service Information Record

Reason For Submittal: ☐ Resign ☐ Change (Address, labor rate, etc.) Please highlight/identify
☐ New ☐ Termination (Effective date) ________

☐ Expert Listed Dealer ☐ Expert Unlisted Dealer ☐ Listed Service Distributor
☐ Listed Dealer ☐ Unlisted Dealer ☐ Unlisted Service Distributor

Central Distributor Name ________________

Current Warranty Code No. ________________ Factory Use Only ________________

NOTE: 1. Please type or print.
2. Complete all applicable information for company being registered.

Employer Identification No. (00-000000) OR Social Security No. (000-00-0000)*

Company Name | *Printed Name of Social Security No. Holder

Business Address | Are You A: (you must check one) Years in Business ________
☐ Corporation ☐ Partnership ☐ Sole Proprietor ☐ Other

City | State/Province/Country | Postal/Zip Code | Mailing Address (P.O. Box)

Business Phone No. and/or 800 No. ( ) | Business Fax No. ( ) | City | State/Province/Country | Postal/Zip Code

Business E-Mail Address | Shop Labor Rate $ | Service Distributor Name

Owner Name(s) | City | State/Province/Country | Postal/Zip Code

Office Manager Name | General Manager Name | Parts Manager Name

Service Manager Name | Certification Number

Mechanics: Name | Certification Number

Name | Certification Number

Engine Lines:
☐ B&S ☐ Sales ☐ Service
☐ Tecumseh ☐ Sales ☐ Service
☐ Wisconsin ☐ Sales ☐ Service
☐ Honda ☐ Sales ☐ Service
☐ Kawasaki ☐ Sales ☐ Service
☐ Other ________

Market Categories:
Commercial ☐ Sales ☐ Service Lines ________
Homeowner ☐ Sales ☐ Service Lines ________
Industrial ☐ Sales ☐ Service Lines ________
Professional ☐ Sales ☐ Service Lines ________

Master Manual Type.
Electronic Type ________ Qty. ____ Fiche Qty. ____ Paper Qty. ____

Facility Sq. Ft. ________ Showroom Sq. Ft. ________ Shop Sq. Ft. ________ Overhead Door ☐ Yes ☐ No

Operations: Posted Hours M ____ T ____ W ____ TH ____ F ____ SA ____ SU ____ Other ____

Services Offered ☐ Mobile (on site) ☐ Pick up & Delivery (Truck ____ Trailer ____)

Warranty Submitted Via: ☐ Mail ☐ Fax ☐ EDI

Shop Has all tools for status selected ☐ Yes ☐ No Tools on order for status selected (Attach form)

Inventory (See Requirements):
Engines Stocked (Attach List) ________ Parts Value (Attach List) ________

Yellow Page Participation (required for Expert & Listed Status). Fee for participation **must** be paid to Central Distributor.
Listed Under Category (describe) ________

I Certify That The Above Statements Are Correct

Dealer Signature | Title | Date

Service Distributor Signature | Title | Date

Central Distributor Signature | Title | Date

DISTRIBUTION: APPLICANT – Goldenrod Copy
SERVICE DISTRIBUTOR – Pink Copy
CENTRAL DISTRIBUTOR – Yellow Copy
KOHLER CO. – White Copy

TP-2485-A
9/96 Rev. 11/00

A Service Information Record form (TP-2485-A) must be on file at Kohler Co. before a service account will be authorized to do warranty repairs.

Important: Section 6109 of the IRS Code requires recipients of payments to give their identifying number to payers.

Failure to supply or provide a correct Fed. I.D. or Social Security number will result in a 20% net withholding payable to the IRS.

B. Warranty Repair Authorization
Only registered Kohler Service Accounts are authorized to perform Kohler engine warranty repairs. A Service Information Record form (TP-2485-A) must be completed, signed, and on file at Kohler Co. before a service account will be authorized to do warranty repairs. These forms are to be submitted through your Central Distributor.

To change your Retail Labor Rate or Warranty Discount information, have your Central Distributor complete a new Service Information Record (TP-2485-A) and submit the updated information to Kohler Co. Change to the Retail Labor Rate or Warranty Discount must be received at Kohler Co., Kohler, Wisconsin, 30 days prior to the effective date of change.

The information on the Service Information Record will be used by Kohler Co. for warranty processing and update mailings. If **any** of the information changes (company name, address, ownership, key personnel, etc.), be certain to notify your Central Distributor, so they can update their records. They will submit the updated data to Kohler Co.

C. Manufacturing Defects Covered
The warranty applies to repair and replacement of defective parts caused by faulty material and/or workmanship in manufacture. It does not apply to defects caused by negligence in servicing or operating an engine.

The following conditions cannot be considered under warranty:

- Normal wear.
- Routine tune-up or adjustment.
- Damage due to improper handling or accident.
- Damage due to operating at speeds or load conditions contrary to published specifications.
- Damage due to improper or insufficient lubrication.
- Damage from overheating due to clogged air intake and cooling fins.
- Damage caused by improperly serviced or inadequate air cleaner.
- Damage due to improper storage.

D. Major Warranty Repair
If an engine is severely damaged and requires a new short block, miniblock, or engine for replacement, first contact your Service or Central Distributor for approval.* Under those conditions, the failed engine or block must be retained.

When you have received Service or Central Distributor approval* and it is determined that the engine involved is under warranty, promptly repair the engine, then submit a properly filled in Warranty Claim Report (see Section 6) to Kohler Co. **within 30 days** after making the repair.

E. Retaining Failed Parts
A claim number is imprinted on each Warranty Claim Report. Tag all parts replaced under a particular warranty claim with the corresponding claim number and keep those parts until you have received your warranty reimbursement. Kohler Co. may request return of some parts for study, but if specific instructions are not given prior to receipt of your reimbursement check, the failed parts may be discarded.

NOTE: Do not return failed parts unless you have received instructions and an Engine Warranty Return (EWR) Number from the Kohler Co.

F. Return of Failed Parts
When Kohler Co. does request the return of failed parts, formal instructions, plus a label with an EWR Number, will be issued to the service account involved. This label must be used to return the part or parts requested. The instructions will include directions for the return shipment.

NOTE: Do not return failed parts unless you have received instructions and an EWR Number from the Kohler Co.

Keep a record of the EWR Number for future reference.

G. Disputed, Questionable, Unusual Warranty, or Policy Adjustments
In the event a customer requests or insists on a warranty repair that, in your opinion, is not covered by the Kohler Limited Engine Warranty, offer the customer one of the following options:

1. Repair the engine and charge the customer with the understanding that you will issue reimbursement, if the claim is approved. Complete a Warranty Claim, (see Section 6), and an Engine Inspection Data Record (TP-2435), and have the damaged parts reviewed by your Central Distributor representative. If the claim is approved, have the Central Distributor representative note authorization for the repair by signing box 17 of the claim, reimburse the customer for the charges, and send the completed Warranty Claim and Engine Inspection Data Record to Kohler Co., Engine Warranty, Kohler, Wisconsin 53044 for payment.

*Expert classifications are exempt from approval requirements.

2. If the customer is willing to wait for a warranty decision prior to having the services performed, complete a Warranty Claim, and an Engine Inspection Data Record. Have your Central Distributor representative review the failed parts, Warranty Claim, and Engine Inspection Data Record. If the claim is approved, have the representative note authorization for the repair by signing box 17 of the claim, perform the repair, and send the completed Warranty Claim and Engine Inspection Data Record to Kohler Co., Engine Warranty, Kohler, Wisconsin 53044 for payment.

3. If the customer insists on a decision by Kohler Co., complete an Engine Inspection Data Record and a Warranty Claim. Check the "DISPUTEDWARRANTY" box at the top of the claim. Contact the Kohler Service Department for an EWR Number. This number should be placed on the outside of the return carton. Send the completed Warranty Claim, and Engine Inspection Data Record and the relevant engine parts, freight prepaid, to Kohler Co., Engine Warranty – Disputed Claim, Bldg. 604, Kohler, Wisconsin 53044.

   NOTE: If you are located outside the continental U.S., send only the completed Warranty Claim and Engine Inspection Data Record to Kohler Co., Engine Warranty, Kohler, Wisconsin 53044. If the failed parts are needed to make the warranty decision, Kohler Co. will contact you with specific instruction concerning the return of the failed parts.

4. If a customer insists on warranty coverage for a situation you feel is not covered by the standard policy, contact the Central Distributor for a "Policy Adjustment" Authorization. The Central Distributor must fill out and sign the Policy Adjustment Evaluation Form (TP-2466-A) and attach it to the Warranty Claim.

Kohler Co. will advise you regarding its decision. If the repair in question is determined to be covered by warranty, payment will be made. If the customer has already paid for the repair, issue reimbursement for **all** charges paid relating to the Kohler engine warranty.

If, for some reason, the request for warranty consideration is denied, or a partial allowance is offered, you will be advised of our findings, along with the reasons for our decision.

H. Engines Manufactured Over 3 Years Ago
A verification of the date of purchase (Example: Bill of Sale, Receipt or Invoice) must accompany the Warranty Claim for all engines that are 3 or more years old. The following chart will aid in determining the year of manufacture:

Serial Number Significance

Year of Manufacture identified by:

1. A Letter
2. First Two Digits/ If Seven Digit Number
3. First Two Digits/If Eight or Ten Digit Number

E-172452 — **9276430** — **10026692** — **1501897591**

A	1965	10-19	1969	10	1980	24	1994
B	1966	20-29	1970	11	1981	25	1995
C	1967	30-39	1971	12	1982	26	1996
D	1968	40-49	1972	13	1983	27	1997
E	1969	50-59	1973	14	1984	28	1998
		60-69	1974	15	1985	29	1999
		70-72	1975	16	1986	30	2000
		73-79	1976	17	1987	31	2001
		80-89	1977	18	1988	32	2002
		90-94	1978	19	1989	33	2003
		95-99	1979	20	1990	34	2004
				21	1991	35	2005
				22	1992	36	2006
				23	1993		

Remaining digits are a factory code.

Section 4 – Warranty Service Parts

A. Policy
Service parts, short blocks, miniblocks, and accessory kits are warranted against manufacturing defects in workmanship and material for a period of 90 days from date of purchase by the original user.

B. Defective Service Parts (New Inventory)
When a part from new service part inventory is found to be defective in material or workmanship, file a Warranty Claim as described in Section 6.

Short blocks, miniblocks, and engines must have Central or Service Distributor approval* with signatures.

Transportation costs for parts replacement will not be reimbursed.

C. Defective Service Parts (Installed)
If a new service part was installed by an authorized Kohler service outlet, and failed within 90 days after installation, submit a Warranty Claim for parts and labor as described in Section 6.

For service parts installed by persons other than authorized Kohler service outlets, and failed within 90 days from date of purchase, submit a Warranty Claim and proof of purchase for the defective part only (no labor), as described in Section 6.

All short blocks, miniblocks, and engines must have Central or Service Distributor approval* with signatures.

If the defective new parts are components of an assembly, repair the assembly by replacing the defective parts whenever this is economically feasible. For example, if the bearing plate on a short block assembly is cracked, due to obvious material defect, replace the bearing plate and submit a warranty claim for the repair.

D. Defective Service Parts (Installed During Engine Warranty Period)
Warranty coverage for components installed during an engine warranty period shall consist of the duration of the engine warranty coverage*** or 90 days, whichever is greater, provided the warranty installation is performed by an authorized Kohler service outlet.

E. Warranty Options and Accessories

1. **Options (Factory Installed)**
   All factory installed options are warranted against defects in workmanship or material for the normal engine warranty period.***

2. **Accessories (Field Installed)**
   All field installed accessories are warranted against defects in material and workmanship for the duration of the engine warranty period*** or 90 days, whichever is greater, provided the installation was performed by an authorized Kohler service outlet.

***Except consumable items such as mufflers and maintenance items.

Section 5 – Warranty Exclusion

A. Non-Reimburseable Items

1. Repairs required to correct failures caused by neglect, normal wear, improper lubrication or abuse. Kohler Co. warranty covers defective workmanship and materials only.
2. Parts and labor supplied by the user or any unauthorized repair facility.
3. Normal maintenance, adjustments, or consumable items, such as fuel, spark plugs, filters, lubricating oil, and hoses.
4. Parts and accessories not installed or supplied by Kohler Co.
5. Rental of another engine or other related equipment while engine repairs are in progress.
6. Telephone, facsimile, and/or other related communications expenses.
7. Replacement and accessory parts not supplied by Kohler Co. and damages resulting from their installation.
8. Loss of revenue resulting from the failure.
9. Loss or damage to personal property.
10. Transportation charges accrued during transportation of failed unit or equipment.*

*Expert classifications are exempt.

Section 6 – Claims Procedure

NOTE: Warranty Claims received without required information **WILL BE RETURNED!**

A. Responsibility for Submitting Proper and Completed Warranty Claim Forms

Warranty repairs and completion of properly filled out warranty claim forms are the responsibility of the authorized service outlet. It is the responsibility of the service outlet to review each claim for thoroughness, authenticity, and accuracy of information. Warranty claims will not be considered complete unless all the information requested on the claim form is filled in. Incomplete or inaccurate claims will be returned to the service outlet. Claim forms received more than 30 days after warranty repairs are completed will not be accepted. Complete engines, short blocks, and miniblocks must be approved by the Central or Service Distributor.* When authorized, the signature of the person authorizing, and date, must be on the warranty claim.

*Expert classifications are exempt.

B. Warranty Claim Report Forms

Three different Warranty Claim Report Forms are accepted by Kohler Co. – the OPEESA (Outdoor Power Equipment and Engine Service Association), the OPEI (Outdoor Power Equipment Institute), and ESA (Engine Service Association) Warranty Claim Forms. The OPEESA Warranty Claim Form is illustrated, and instructions for completing it are given. Please follow the instructions when making out the report. Do not combine claims for more than one repair on a single form – each claim must be filed separately. Claims must be received at Kohler Co. **within 30 days** after warranty repairs are made. Send the white copy of the claim directly to Kohler Co., Engine Warranty, Kohler, Wisconsin 53044, except in cases where Central or Service Distributor approval* is required. (See Section A.)

C. Warranty Claim Instructions

The Outdoor Power Equipment and Engine Service Association, in conjunction with the manufacturers who use it, have developed the following warranty claim form. Follow these instructions when filling out a claim.

OPEESA
OUTDOOR POWER EQUIPMENT AND ENGINE SERVICE ASSOCIATION

WARRANTY CLAIM

NO. A 1191554

2 WARRANTY CODE NO.

PLEASE TYPE OR PRINT CLEARLY
1 TYPE OF CLAIM (CHECK ONLY ONE)
☐ Warranty Repair ☐ New Defective Service Parts
☐ Policy Adjustment ☐ Questionable/Disputed

✓ FOR
☐ Generac PS
☐ Kohler
☐ Tecumseh
☐ US Motor Power

4 WARRANTY PERFORMED BY ☐CD ☐SD ☐DEALER
Firm Name
Address
City State
Phone Zip Code
Signed

3 OWNER'S LAST NAME
COMMERCIAL USER ☐ YES ☐ NO
FIRST MI
ADDRESS
CITY STATE
PHONE ZIP
Customer Signature

Purchased Date	Failure Date	Repair Date
Mo. Day Yr.	Mo. Day Yr.	Mo. Day Yr.

6 HOURS USED 7 UNIT ORIGINALLY SOLD BY

5 Engine/Transmission Short Block/Model No | Spec No. | D.O.M. or Serial No.
Equipment Manufacturer | Type of Equipment | Engine Received ☐ Mounted ☐ Detached

8 PARTS HAVE BEEN
☐ Returned to Factory ☐ Returned to Central ☐ Retained & Tagged

9 DEFECTIVE PART NUMBER
10 FAILURE SUFFIX

FAILURE SUFFIXES

AW- Assembled Wrong	FM- Foreign Material	SD- Shipping Damage
BC- Broken/Cracked	IF- Improper Fit	SG- Scored/Galled
BL- Blown	LK- Leaked	SS- Stuck/Seized
BT- Bent/Twisted	MI- Missing	ST- Stripped
CD- Porous/Casting Deficiency	ML- Magnet Loose	UO- Unknown/Other
CL- Cams Loose/Off	NS- Not Seating	VC- Valve/Clearance
CP- Corroded/Pitted	NY- Noisy	WN- Worn
EF- Electric Failure	OA- Out of Adjustment	WP- Warped
	PM- Part Made/Machined Incorrectly	

11 Condition Found/Probable Cause of Failure (Word "Defective" Not Sufficient)

12 Job Number/Work Performed. If Necessary to Remove & Replace (R&R) Engine from Equipment, then Show R&R Separately.

13 Miscellaneous	Dollars	Cents
Freight/Postage Allowance Attach Freight Bill		

14 Labor	HRS.	MINS./TENTHS	JOB#
Repair 1			
Repair 2			
Repair 3			
Misc. Labor			
R & R			
TOTAL			

16 Part Number	Qty.	Description

15 FACTORY USE ONLY
OEM Code
Defect Code #
End Use Code #
Division

17 Engine/Short Block/Transmission (Authorized Signature Req'd)
Authorized By
Firm Name

ESA 1578 REV 12/96

Box 1: Check box for type of claim and manufacturer.

Box 2: Enter Warranty Code Number.

Box 3: Enter engine owner's name, address, and have owner sign.

Box 4: Enter name of repairing dealer, check box for type of dealer, have technician sign. Enter dates as requested.

Box 5: For regular Engine Warranty Claim – fill in completely, giving all information requested.

A. **Parts new defective in stock –** Enter "parts" in engine/transmission model number section and leave the remaining sections blank.

B. **Short block or miniblock new defective in stock –** Enter "parts" in engine/transmission model number section. List the defective assembly part number in the type or spec. number section. List the serial number in the code or serial number section. Leave the remaining sections blank.

C. **Parts, short block, or miniblock found defective within 90 days after installation –** Enter parts/engine model number (Example: Parts/M8) in engine/transmission model number section. For a miniblock or short block, list the part number in the type or spec. number section. List the serial number of the defective short block or miniblock in the code or serial number section and complete the remaining sections.

NOTE: Boxes 1, 2, 4, 8, and 16 are required for defective service parts. In addition, box 17 must be signed* by a distributor representative for short block, miniblock, or engine replacement.

Box 6: Record hours used.

Box 7: Enter name of original seller of equipment.

Box 8: Check box describing parts disposition.

Box 9: Enter part number of defective part.

The part number should normally not be an assembly part number. The actual part number of the component within an assembly that failed should be shown. For example, a wrist pin retainer failure caused extensive damage to the cylinder bore requiring a miniblock assembly. The Kohler Engine Failure code in this case would be the part number of the retainer, 235811. You would **not** enter the miniblock assembly number in this case.

The only time an assembly number should be entered is when no parts breakdown is given for the failed assembly (Example: a magnet came loose on a flywheel. There is no service part number for the flywheel magnet, therefore, the part number for the flywheel would be listed).

Box 10: Enter failure suffix from listing on claim, also shown on next page.

Box 11: Conditions Found – Describe in detail the failure. If more space is required attach a note.

Probable Cause of Failure – List in detail the most probable cause.

Box 12: Enter the job numbers of work performed as stated in the Flat Rate Schedule and indicate time spent in repairing the engine. When it becomes necessary to remove an engine to make the repair, enter job number 4000 for removing and reinstalling (R & R) as a separate item. Check against the flat rate maximums.

The flat rate times have been established using facilities and equipment that all Service Accounts should have available. If your repair time exceeds the flat rate, and additional labor allowance is requested, please send a note of explanation so consideration can be given.

Important: Using the incorrect Flat Rate Schedule could result in incorrect payment and/or delay in the processing of your claim.

Box 13: Fill in freight allowance details if applicable.

Box 14: Enter labor time in hours and decimal fractions (Example: 1.5).

Box 15: Leave blank – factory use only.

Box 16: List part numbers and description of each part replaced.

Box 17: Must be filled in and signed* by a distributor representative when any short block, miniblock, or engine is replaced. An Engine Inspection Data Record (TP-2435) should be completed and submitted with the Warranty Claim.

*Expert classifications are exempt.

Failure Type Suffix			
AW	Assembled Wrong	**OA**	Out of Adjustment
BC	Broken/Cracked	**OB**	Out of Balance
BL	Blown	**PK**	Packing Material Defective
BT	Bent/Twisted	**PM**	Part Made/Machined Incorrectly
CD	Porous/Casting Deficiency	**PP**	Paint Peeling
CL	Came Loose/Off	**SD**	Shipping Damage
CP	Corroded/Pitted	**SG**	Scored/Galled
DE	Dented	**SS**	Stuck/Seized
EF	Electric Failure	**ST**	Stripped
FM	Foreign Material	**TR**	Trucking Damage
IF	Improper Fit	**UO**	Unknown/Other
LK	Leaked	**VC**	Valve/Clearance
MI	Missing	**WW**	Weak Weld
ML	Magnets Loose	**WN**	Worn
NS	Not Seating	**WP**	Warped
NY	Noisy	**ZZ**	Others

Section 7 – Reimbursement Procedures

A. Policy
Kohler Co. will reimburse authorized and registered service outlets for all approved warranty claims. U.S. and Canadian outlets are reimbursed by check. International outlets receive reimbursement from their Central Distributor.

B. Reimbursement Calculation Details
Warranty reimbursement is calculated by using the following formulas for each respective worldwide service outlet classification.

1. **U.S.A.† & Canada, Non-Expert**
   Total Credit = Parts Net Price + Parts Profit# + Freight + Labor ($33/hr. max.) + Miscellaneous Costs

   #Parts Profit = Net Price x
20%	Parts
10%	Short Block
	Miniblock
	Engine**

2. **U.S.A. & Canada, Expert**
   Total Credit = Parts List Price + Freight + Labor (Full Shop Rate) + Miscellaneous Costs (Diagnostic & Pickup and Delivery)

3. **International, Non-Expert**
   Total Credit = Parts Net Price + Parts Profit# + Handling Allowance + Labor + Miscellaneous Cost

   #Parts Profit = Parts Net Price x
20%	Parts
10%	Short Block
	Miniblock
	Engine**

4. **International, Expert**
   Total Credit = Parts List Price + Freight + Labor (Full Shop Rate) + Miscellaneous Costs (Diagnostic & Pickup and Delivery)

**NOTE: OHC/Command/Courage Series Engine replacement use list price and no profit on parts.

C. Freight Cost U.S.A & Canada (FOB and Truck)
Freight costs for warranty work will be reimbursed where a short block, miniblock, or service engine is required. Submit a warranty claim form and a copy of the **freight bill**. No transportation costs for individual parts will be reimbursed.

When shipped by a distributor and a freight bill is not available, write in box 13 the FOB charges you received from your distributor and have the Central Distributor representative initial the charge.

†Some states have specific warranty laws that supersede the following.

Section 8 – Engine Inspection Data Record

A. Engine Inspection Data Record Instructions
Engine Inspection Data Record (TP-2435) must be completed for the following situations: policy adjustments, disputed warranty, or when a short block, miniblock, or engine is required.

Section 1 of the Engine Inspection Data Record should be filled in immediately, when you receive an engine that has had a major failure within the warranty period. If possible, review it while the customer is still present, as you will probably need their input to answer some of the questions. Section 1 should be completed and ready for your distributor representative when they arrive to make their analysis.

Section 2 should be completed, at the time the distributor representative makes their review and analysis, and in the following situations.

1. If the Service Distributor or Expert classified outlet representative cannot make a final decision, due to inconclusive evidence or information. Assistance from the Central Distributor or factory will be required.
2. If the engine is on a piece of commercial equipment more than six months old, and/or the engine has more than 500 hours of running.
3. If the engine has not yet reached the above criteria (less than six months old, less than 500 hours), you need only complete that portion of Section 2 which pertains to the actual failure. For example, if the connecting rod has seized to the crankshaft you would only fill out the "Connecting Rod", "Crankshaft Rod Journal", and "Evaluation Performed By" segments of Section 2. However, if you notice anything else that could have been a contributing factor, such as burned oil deposits on the piston (indicating possible overheating and/or oil breakdown), that should also be noted.

B. Engine Inspection Data Record

Engine Inspection Data Record

To facilitate accurate evaluation:

- enter as much information as possible
- provide as many dimensions as possible.
- mark location of break or crack on drawing
- record conditions found with check mark (X) whenever possible

SECTION 1 OWNER AND EQUIPMENT INFORMATION

Owner's Name	Street Address		
City	State	Zip Code	Phone No. ( ) -
Model No.	Spec. No.		Serial No.
Type Equipment		Manufacturer of Equipment	
Date Purchased	Date Failed	Hours Used	Times Used
Previous Repairs ☐ YES ☐ NO	Warranty Claim No.		

USAGE/MAINTENANCE INFORMATION

Oil type: ☐ 30W ☐ 10W-30 10W-40 ☐ 5W-20 5W-30 ☐ Other ________	Hours since last oil change?
How often is the oil level checked? ☐ Every time ☐ Never ☐ Other ________	Must oil be added between changes? ☐ Yes ☐ No How much? ________
Was an oil additive used? ☐ Yes ☐ No What brand? ________	How often is the air cleaner checked? Precleaner ________ Element ________
Was it ever replaced or cleaned? Precleaner: ☐ Yes ☐ No Element: ☐ Yes ☐ No	How recently? Precleaner ________ Element ________
Were any adjustments made to the carburetor or governor? ☐ Yes ☐ No If yes, specify ________	By whom? ☐ Customer ☐ Dealer

PRELIMINARY EXAMINATION

Air Cleaner Assembly

Type: ☐ Dry ☐ Precleaner ☐ Remote ☐ Oil Bath ☐ Tri-Phase

1. Wing Nut: ☐ Factory Original ☐ Non-standard replacement — Wing nut seal: ☐ Intact ☐ Separated ☐ Missing
2. Outer Cover: ☐ Good condition ☐ Center hole oblong ☐ Other damage (specify) ________
3. Precleaner: ☐ Clean ☐ Dirty ☐ Plugged ☐ Oiled ☐ Dry ☐ Torn ☐ Other damage ________
4. Inner Cover: ☐ Retaining seal/nut in place ☐ Center hole oblong ☐ Distorted ☐ Other damage ________
5. Element: ☐ Clean ☐ Dusty ☐ Dirty ☐ Plugged ☐ Missing ☐ Dry ☐ Non-factory replacement ☐ Other damage ________
6. Element seals: ☐ Pliable ☐ Hard ☐ Sealing ☐ Leaking ☐ Other damage ________
7. Air cleaner base: ☐ Tight ☐ Loose ☐ Screw(s) missing ☐ Distorted/Cracked ☐ Breather hose detached ☐ Other damage ________

Crankcase Oil

1. Amount on dipstick: ☐ Overfilled ☐ Full ☐ Above "add" ☐ Below "add" ☐ No reading
2. Condition of oil: ☐ New ☐ Used ☐ Dirty ☐ Black ☐ Thick/Sticky ☐ Burnt smelling ☐ Fuel diluted
3. Quantity of oil: Amount drained: ________ Amount req'd. ________

Observations: ☐ Metal chips present ☐ Sludge present ☐ Non-factory oil filter

TP-2435

(Continued on page 2)

Preliminary Examination (continued)

Cooling System

1. Flywheel Screen:
☐ Clean ☐ Plugged ☐ Partially blocked (%) ____________

2. Cooling fins:
☐ Clean ☐ Plugged ☐ Partially blocked (%) ____________

3. Engine exterior:
☐ Clean ☐ Dirty ☐ Oily ☐ Evidence of prior disassembly or repair ☐ Visible oil leaks (where) ____________

Carburetor and Fuel Supply

1. Condition of carburetor:
☐ Okay ☐ Broken ☐ Loose ☐ Shafts worn ☐ Dirt in throat

2. Settings:
☐ Main fuel adj. ____________ ☐ Idle fuel adj. ____________

3. Condition of fuel:
☐ Clean ☐ Fresh ☐ Stale ☐ Contaminated (water, debris, etc.)

Governor

1. Components:
☐ Intact ☐ Missing ☐ Modified ☐ Bent/Broken

2. Function:
☐ Operative ☐ Inoperative ☐ Modified ☐ Misadjusted

Dirt Ingestion

1. Is there evidence of possible dirty entry via:
☐ Air cleaner ☐ Carburetor ☐ Breather ☐ Gasket/Seal ☐ Oil fill opening ☐ Other ____________

Spark Plug

Spark Plug	Cylinder 1	Cylinder 2	Combustion Deposits	Cylinder 1	Cylinder 2
Gap	in.	in.	Light	☐	☐
Make			Heavy	☐	☐
Number			Color	☐	☐

SECTION 2 EVALUATION PERFORMED BY

Evaluator	Date
Company Name	Type of Acct. ☐ Central Distributor ☐ Service Distributor ☐ Service Dealer
Address	

City	State	Zip Code	Phone No.

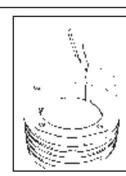
TEAR DOWN ANALYSIS

VALVES	CYLINDER 1		CYLINDER 2	
	Intake	Exhaust	Intake	Exhaust
Stuck	☐	☐	☐	☐
Face Burned	☐	☐	☐	☐
Bent	☐	☐	☐	☐
Guide Worn	☐	☐	☐	☐
Not Damaged	☐	☐	☐	☐

CLEARANCE: (COLD)	CYLINDER 1	CYLINDER 2
Intake	in.	in.
Exhaust	in.	in.

CONNECTING ROD	CYLINDER 1	CYLINDER 2
Discolored	☐	☐
Broken	☐	☐
Bearing Scored	☐	☐
Cap Screws Loose	☐	☐
Dipper Bent	☐	☐
Dipper Broken	☐	☐
Rod Seized to Crankpin	☐	☐
Rod OK - Not Damaged	☐	☐

PISTON RINGS	CYLINDER 1	CYLINDER 2
Production Rings	☐	☐
Service Rings	☐	☐
Rings Free in Grooves	☐	☐
Rings Stuck in Grooves	☐	☐
End Gap:		
Top	________ in.	________ in.
Center	________ in.	________ in.
Oil	________ in.	________ in.

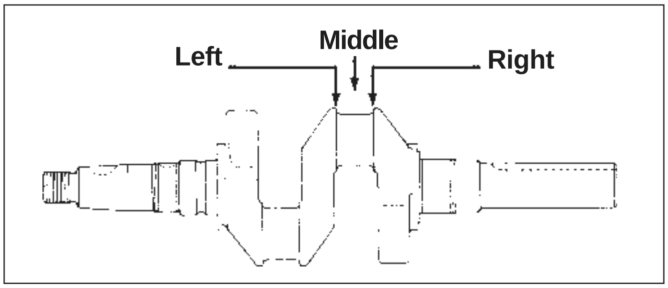


Note: For Crankshaft, Pistons & Cylinder Bore Measurements – See Page 3.

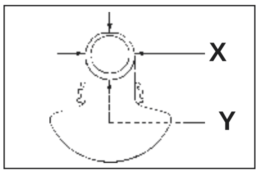
(Continued on page 3)

Tear Down Analysis (continued)

CRANKSHAFT ROD JOURNAL



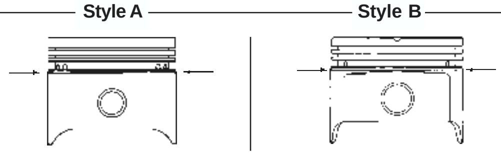
	CYLINDER 1	CYLINDER 2
Scored	☐	☐
Worn	☐	☐
Unmeasureable	☐	☐
Broken	☐	☐
Not Damaged	☐	☐
Others		
Maximum Wear Spec.		



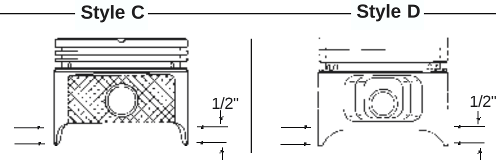
	CYLINDER 1		CYLINDER 2		MAX. OUT OF ROUND
	X	Y	X	Y	
Left					
Middle					
Right					
Max. Taper					

PISTON

Select the following piston type and measure diameter using appropriate method.



Measure just below oil ring groove and at right angle to piston pin.



Measure 1/2 inch above the bottom of the skirt and at right angle to piston pin.

Measure 6 mm (0.24 in.) above the bottom of piston skirt at right angles to piston pin.

	CYLINDER 1	CYLINDER 2
Scored	☐	☐
Worn	☐	☐
Cracked	☐	☐
Broken	☐	☐
Ring Grooves Worn	☐	☐
Galled	☐	☐
Discolored	☐	☐

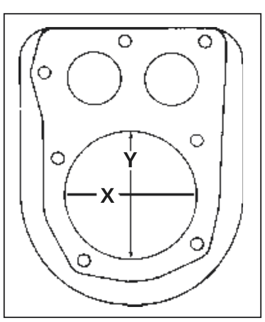
	CYLINDER 1	CYLINDER 2
Scratched	☐	☐
Not Damaged	☐	☐
Others ______		

	CYLINDER 1	CYLINDER 2
Piston Diameter	______	______

CYLINDER BORE

	CYLINDER 1	CYLINDER 2
Bore Scored	☐	☐
Worn	☐	☐
Not Damaged	☐	☐
Others ______		

MAXIMUM WEAR SPEC. ______



	CYLINDER 1		CYLINDER 2		MAX. OUT OF ROUND
	X	Y	X	Y	
Top					
Center					
Bottom					
Max. Taper					

Section 9 – Flat Rate Schedules

Command Pro CS Series Flat Rate Schedule		Maximum Time (Hr.)
Job No.	**Description**	**CS4-12**
	Major Repairs	
4000	Engine R & R	1.0
4002	Engine R & R From Generator Set	1.0
4012	Major Overhaul (Includes Valve Service)	4.0
4013	Minor Overhaul (Excludes Valve Service)	3.0
4015	Connecting Rod	2.0
4016	Piston and/or Rings	2.0
	Crankshaft	
4020	Crankshaft & Main Bearing R & R	2.3
4021	Crankshaft – PTO Seal	1.2
4022	Crankshaft – Flywheel Seal	2.2
4023	Crankshaft & Connecting Rod	2.5
4024	Balance Shaft – R & R	1.5
	Camshaft & Valves	
4028	Lifters	1.5
4029	Valve R & R (No Grinding)	1.1
4030	Valve Tappet Adjustment	0.2
4031	Valve Grinding	1.2
4033	Valve Spring Replacement	0.9
4034	Valve Cover Gasket and/or Breather	0.3
4035	Camshaft R & R	1.5
4039	Rocker Arm	0.2
4046	Ignition Module R & R	1.0
4047	Flywheel R & R	1.0
	Charging	
4050	Regulator – Test & Replace	0.5
	Major Repairs	
4051	Stator – Test & Replace (Includes Flywheel R & R)	1.5
	Starter	
4060	Retractable – R & R, Replace Rope & Spring	1.0
4061	Starting Motor – Bendix Type R & R	1.2
4064	Starter Drive R & R	0.5
4065	Starter Solenoid R & R	0.5
	Carburetor & Air Intake	
4070	Carburetor R & R	0.5
4071	Carburetor – Rebuild (Includes R & R)	1.0
4072	Carburetor – Adjust	0.1
4073	Air Cleaner – Damage in Shipment	0.1
4074	Fuel Tank – R & R	0.2
4076	Intake Manifold	0.5
	Miscellaneous Repairs	
4080	Cylinder Head and/or Gasket – Replace/each	0.8
4082	Shrouds only – R & R	0.2
4083	Oil Pan, Closure Plate, and/or Gasket –Replace	1.3
4084	Muffler – Replace	0.2
4085	Governor – Adjustment	0.2
4086	Governor R & R	1.6
4088	Crankshaft – Grinding (ENTER NET COST)	–
4089	Crankcase – Boring (ENTER NET COST)	–
4090	Governor Seal Replacement	1.6
4091	Oil Sentry Module	0.3
4092	Oil Sentry Float	1.5
4093	Gear Reduction R & R	0.6

Courage & Command Single Flat Rate Schedule		Maximum Time (Hr.)		
Job No.	Description	SV470-600	CH5,6	CH11-16 CV11-495
	Major Repairs			
4000	Engine R & R	1.0	1.0	1.0
4001	Generator Set R & R – Motor Home	–	2.0	2.0
4002	Engine R & R From Generator Set	–	1.0	1.0
4010	Short Block Replacement	2.0	1.0	1.5
4012	Major Overhaul (Includes Valve Service)	–	3.0	4.0
4013	Minor Overhaul (Excludes Valve Service)	–	2.5	3.0
4015	Connecting Rod	1.8	2.0	2.5
4016	Piston and/or Rings	1.8	2.0	2.5
	Crankshaft			
4020	Crankshaft & Main Bearing R & R	1.5	2.5	3.0
4021	Crankshaft – PTO Seal	0.3	0.5	0.5
4022	Crankshaft – Flywheel Seal	0.6	1.5	1.5
4023	Crankshaft & Connecting Rod	–	2.5	2.5
4024	Balance Shaft/Weights – R & R	1.5	–	1.5
	Camshaft & Valves			
4028	Lifters	–	–	1.0
4029	Valve R & R (No Grinding)	1.2	1.0	1.0
4030	Valve Adjustment	0.5	0.5	–
4031	Valve Grinding	–	1.2	1.2
4033	Valve Spring Replacement	–	0.5	1.0
4034	Valve Cover Gasket and/or Breather	0.3	0.3	0.5
4035	Camshaft R & R	1.3	1.5	2.0
4037	Camshaft PTO Seal	–	0.5	–
4039	Rocker Arm	0.6	0.7	0.7
	Ignition			
4046	Ignition Module R & R	0.3	1.0	1.0
4047	Flywheel R & R	0.5	1.2	1.2
4048	Spark Advance Module	–	–	0.5
	Charging			
4050	Regulator – Test & Replace	0.5	–	0.5
4051	Stator – Test & Replace (Includes Flywheel R & R)	0.8	1.0	1.5
	Starter			
4060	Retractable – R & R, Replace Rope & Spring	–	1.0	1.0
4061	Starting Motor – Bendix Type R & R	0.3	0.5	0.5
4063	Starter – Bendix Rebuild (Includes R & R)	1.0	1.0	1.0
4064	Starter Drive R & R	0.7	1.0	1.0
4065	Starter Solenoid R & R	–	0.5	0.5
	Fuel System & Air Intake			
4067	Carburetor Solenoid (Includes Test)	0.3	–	0.3
4070	Carburetor R & R	0.5	1.0	0.5
4071	Carburetor – Rebuild (Includes R & R)	1.0	1.5	1.0
4072	Carburetor – Adjust	0.2	0.3	0.3
4073	Air Cleaner – Damage in Shipment	–	0.5	0.3
4074	Fuel Tank – R & R	–	1.0	0.5
4075	Fuel Pump – R & R	0.3	0.3	0.3
	Miscellaneous Repairs			
4080	Cylinder Head and/or Gasket	1.0	1.0	1.0
4082	Blower Housing/Shrouds only – R & R	0.2	0.5	0.5
4083	Oil Pan, Closure Plate, and/or Gasket – Replace	0.8	–	1.5
4084	Muffler – Replace	0.3	0.3	0.3
4085	Governor – Adjustment	0.3	0.5	0.5
4086	Governor R & R	1.1	1.5	2.0
4087	Oil Pump R & R	1.4	–	0.5
4088	Crankshaft – Grinding (ENTER NET COST)	–	–	–
4089	Crankcase – Boring (ENTER NET COST)	–	–	–
4090	Governor Seal Replacement	–	–	0.8
4091	Oil Sentry/Oil Temp./Oxygen Sensor	0.3	0.3	0.2
4096	Cam Followers (Includes Valve Adjustment)	1.3	–	–

Command Twin & Aegis Flat Rate Schedule		Maximum Time (Hr.)			
		Command Twin		Aegis	
Job No.	Description	CH18-23,CV17-23 CH/CV730-740	CH/CV25,26 CH/CV745	LV560-675	LH630-760
	Major Repairs				
4000	Engine R & R	2.5	2.5	2.5	2.5
4002	Engine R & R From Generator Set/Welder	4.0	4.0	–	–
4010	Short Block Replacement	3.0	3.0	5.0	5.0
4011	Miniblock	4.0	4.0	6.0	6.0
4012	Major Overhaul (Includes Valve Service)	5.0	5.0	7.0	7.0
4013	Minor Overhaul (Excludes Valve Service)	4.0	4.0	6.0	6.0
4015	Connecting Rod	3.0	3.0	5.0	4.0
4016	Piston and/or Rings	3.0	3.0	5.0	4.0
	Crankshaft				
4020	Crankshaft & Main Bearing R & R	3.0	3.0	2.5	3.8
4021	Crankshaft – PTO Seal	0.5	0.5	0.5	1.5
4022	Crankshaft – Flywheel Seal	1.5	1.5	1.0	1.6
4023	Crankshaft & Connecting Rod	3.0	3.0	1.5	1.5
	Camshaft & Valves				
4028	Lifters	0.5♦	0.5♦	1.0♦	0.5♦
4029	Valve R & R (No Grinding)	1.0♦	1.0♦	3.5♦	2.7♦
4030	Valve Shim Adjustment	–	–	0.5♦	–
4031	Valve Grinding	1.2♦	1.2♦	3.8♦♦	3.0♦♦
4033	Valve Spring Replacement	1.0♦	1.0♦	3.3♦♦	2.5♦♦
4034	Valve Cover Gasket and/or Breather	0.5♦	0.5♦	0.5♦	0.5♦
4035	Camshaft R & R	2.0	2.0	2.5	2.8
4037	Camshaft PTO Seal	–	–	1.8	2.1
4039	Rocker Arm	0.5♦	0.5♦	0.5♦	0.5♦
	Ignition				
4046	Ignition Module R & R (Includes Both Modules)	1.5	1.5	1.5	0.7
4047	Flywheel R & R	1.2	1.2	0.8	1.3
4048	Spark Advance Module/ECU/TPS[1]	1.0	1.0	–	–
4049	Speed Sensor	–	1.0	–	–
	Charging				
4050	Regulator – Test & Replace	0.5	0.5	0.5	0.3
4051	Stator – Test & Replace (Includes Flywheel R & R)	1.5	1.5	1.0	1.5
4052	Wiring Harness R & R♦♦♦	1.0	1.0	1.0	1.0
	Cooling System				
4055	Coolant R & R (Includes Coolant Temp. Switch)	–	–	1.0	0.7
4056	Radiator R & R	–	–	1.5	1.0
4057	Thermostat R & R	–	–	0.5	0.7
4058	Water Pump	–	–	1.7	2.0
4059	Pump Drive Belt	–	–	1.5	1.8
	Starter				
4060	Retractable – R & R, Replace Rope & Spring	0.5	0.5	–	–
4061	Starting Motor – Bendix Type R & R	1.0	1.0	0.5	0.5
4063	Starter – Bendix Rebuild (Includes R & R)	1.0	1.0	1.0	1.0
4064	Starter Drive R & R	1.0	1.0	1.0	1.0
4065	Starter Solenoid R & R	0.5	0.5	0.5	0.5
	Fuel System & Air Intake				
4070	Carburetor R & R	0.5	0.5	0.5	0.7
4071	Carburetor – Rebuild (Includes R & R)	1.0	1.0	1.0	1.0
4072	Carburetor – Adjust	0.3	0.3	0.3	0.3
4073	Air Cleaner – Damage in Shipment	0.3	0.3	0.3	0.3
4075	Fuel Pump – R & R	0.3	0.5	0.3	0.3
4076	Intake Manifold	1.0	1.0	2.0	2.0
4077	Injectors/Fuel Rail	–	1.5	–	–

♦Time allowed is for each cylinder.
♦♦Additional 0.5 for 2nd cylinder.
♦♦♦Additional 0.5 for EFI engines.

[1]ECU-Engine Control Unit; TPS-Throttle Position Sensor.
[A]Plated cylinders cannot be rebored.

Command Twin & Aegis Flat Rate Schedule		**Maximum Time (Hr.)**			
		Command Twin		**Aegis**	
Job No.	**Description**	**CH18-23,CV17-23 CH/CV730-740**	**CH/CV25,26 CH/CV745**	**LV560-675**	**LH630-760**
	Miscellaneous Repairs				
4080	Cylinder Head and/or Gasket – Replace/each	1.0	1.0	3.3♦♦	2.5♦♦
4082	Shrouds only – R & R	0.5	0.5	–	0.3
4083	Oil Pan, Closure Plate, and/or Gasket – Replace	1.0	1.0	1.0	1.0
4084	Muffler – Replace	0.3	0.3	0.3	0.3
4085	Governor – Adjustment	0.5	0.5	0.5	0.5
4086	Governor R & R	1.5	1.5	1.5	1.5
4087	Oil Pump R & R	1.5	1.5	1.5	1.5
4088	Crankshaft – Grinding (ENTER NET COST)	–	–	–	–
4089	Crankcase – Boring (ENTER NET COST)	–	A	–	–
4090	Governor Seal Replacement	0.8	0.8	0.8	0.8
4091	Oil Sentry/Oil Temp./Oxygen Sensor	0.3	0.3	0.3	0.3
4094	Adjust Belt Tension	–	–	–	0.7
4095	Flywheel Cover	–	–	2.3	–

♦Time allowed is for each cylinder.
♦♦Additional 0.5 for 2nd cylinder.
♦♦♦Additional 0.5 for EFI engines.

[1]ECU-Engine Control Unit; TPS-Throttle Position Sensor.
[A]Plated cylinders cannot be rebored.

OHC Flat Rate Schedule		Maximum Time (Hr.)	
		Twin	
Job No.	Description	TH16	TH18
	Major Repairs		
4000	Engine R & R	2.5	2.5
4010	Short Block Replacement	3.0	3.0
4011	Miniblock/Crankcase	4.0	4.0
4012	Major Overhaul (Includes Valve Service)	5.0	5.0
4013	Minor Overhaul (Excludes Valve Service)	4.0	4.0
4015	Connecting Rod	3.0	3.0
4016	Piston and/or Rings	3.5	3.5
	Crankshaft		
4020	Crankshaft & Main Bearing R & R	3.0	3.0
4021	Crankshaft – PTO Seal	0.5	0.5
4022	Crankshaft – Flywheel Seal	2.0	2.0
4023	Crankshaft & Connecting Rod	3.0	3.0
	Camshaft & Valves		
4029	Valve R & R (No Grinding)	4.0	4.0
4030	Valve Tappet Adjustment	0.5	0.5
4031	Valve Grinding	4.0	4.0
4033	Valve Spring Replacement	2.5	2.5
4034	Valve Cover Gasket and/or Breather	0.5	0.5
4035	Camshaft R & R	2.5	2.5
4037	Camshaft PTO Seal	2.0	2.0
4038	Timing Belt R & R	1.5	1.5
4039	Rocker Arm	2.5	2.5
	Ignition		
4046	Ignition Module R & R (Includes Both Modules)	1.5	1.5
4047	Flywheel R & R	0.7	0.7
	Charging		
4050	Regulator – Test & Replace	0.5	0.5
4051	Stator – Test & Replace (Includes Flywheel R & R)	1.0	1.0
	Starter		
4060	Retractable – R & R, Replace Rope & Spring	0.5	0.5
4061	Starting Motor – Bendix Type R & R	0.5	0.5
4063	Starter – Bendix Rebuild (Includes R & R)	1.0	1.0
4064	Starter Drive R & R	1.0	1.0
4065	Starter Solenoid R & R	0.3	0.3
	Carburetor & Air Intake		
4070	Carburetor R & R	1.0	1.0
4071	Carburetor – Rebuild (Includes R & R)	1.0	1.0
4072	Carburetor – Adjust	0.3	0.3
4073	Air Cleaner – Damage in Shipment	0.1	0.1
4074	Fuel Tank – R & R	0.5	0.5
4075	Fuel Pump – R & R	0.5	0.5
	Miscellaneous Repairs		
4082	Shrouds only – R & R	0.7	0.7
4083	Oil Pan, Closure Plate, and/or Gasket – Replace	3.0	3.0
4084	Muffler – Replace	0.3	0.3
4085	Governor – Adjustment	0.5	0.5
4086	Governor R & R	2.5	2.5
4087	Oil Pump R & R	2.0	2.0
4088	Crankshaft – Grinding (ENTER NET COST)	–	–
4089	Crankcase – Boring (ENTER NET COST)	A	A
4090	Governor Seal Replacement	0.8	0.8

[A]Crankcase cannot be rebored

Magnum Flat Rate Schedule		Maximum Time (Hr.)		
		Single	Twin	
Job No.	Description	M8,M10, M12,M14,M16	MV16,MV18,MV20	M18 & M20
	Major Repairs			
4000	Engine R & R	1.0	2.5	2.5
4001	Generator Set R & R – Motor Home	2.0	–	2.0
4002	Engine R & R From Generator Set	1.0	–	3.0
4010	Short Block Replacement	3.0	3.0	3.0
4011	Miniblock Replacement	3.5	–	–
4012	Major Overhaul (Includes Valve Service)	5.0	6.0	6.0
4013	Minor Overhaul (Excludes Valve Service)	4.0	5.0	5.0
4015	Connecting Rod	2.0	5.0	5.0
4016	Piston and/or Rings	2.0	3.0	3.0
	Crankshaft			
4020	Crankshaft & Main Bearing R & R	3.0	5.0	5.0
4021	Crankshaft – PTO Seal	0.5	1.5	0.8
4022	Crankshaft – Flywheel Seal	1.5	1.5	1.5
4023	Crankshaft & Connecting Rod	3.0	5.0	5.0
4024	Balance Gears – R & R	3.0	–	–
	Camshaft & Valves			
4029	Valve R & R (No Grinding) (Each Cylinder)	1.0	1.0	1.0
4030	Valve Tappet Adjustment	1.0	1.0	1.0
4031	Valve Grinding (Each Cylinder)	1.2	1.2	1.2
4032	Valve Guide Replacement	1.5	1.5	1.5
4033	Valve Spring Replacement	1.0	1.0	1.0
4034	Valve Cover Gasket and/or Breather	0.5	0.6	0.6
4035	Camshaft R & R	3.2	4.5	4.5
	Ignition			
4046	Ignition Module R & R	1.0	1.0	1.0
4047	Flywheel R & R	1.2	1.2	1.2
	Charging			
4050	Regulator – Test & Replace	0.5	0.5	1.0
4051	Stator – Test & Replace (Includes Flywheel R & R)	1.5	1.5	1.5
	Starter			
4060	Retractable – R & R, Replace Rope & Spring	1.0	1.0	–
4061	Starting Motor – Bendix Type R & R	1.0	0.5	1.0
4063	Starter – Bendix Rebuild (Includes R & R)	1.5	1.0	1.5
4064	Starter Drive R & R	1.2	1.2	1.2
4065	Starter Solenoid R & R	0.5	0.5	0.5
	Carburetor & Air Intake			
4070	Carburetor R & R	1.0	0.5	0.5
4071	Carburetor – Rebuild (Includes R & R)	1.5	1.0	1.0
4072	Carburetor – Adjust	0.2	0.3	0.3
4073	Air Cleaner – Damage in Shipment	0.3	0.3	0.3
4074	Fuel Tank – R & R	0.5	–	–
4075	Fuel Pump – R & R	0.5	0.3	0.3
4076	Fuel Pump – Rebuild (Includes R & R)	1.0	0.8	0.8
	Miscellaneous Repairs			
4080	Cylinder Head and/or Gasket – Replace/each	1.0	0.6	0.6
4081	Cylinder Head Retorque	0.8	0.4	0.4
4082	Shrouds only – R & R	0.6	0.6	0.6
4083	Oil Pan and/or Gasket – Replace	0.5	1.0	–
4084	Muffler – Replace	0.3	0.3	0.3
4085	Governor – Adjustment	0.5	0.3	0.3
4086	Governor R & R	3.0	4.3	4.3
4087	Oil Pump R & R	–	2.0	2.0
4088	Crankshaft – Grinding (ENTER NET COST)	–	–	–
4089	Crankcase – Boring (ENTER NET COST)	–	–	–

K-Series Flat Rate Schedule		Maximum Time (Hr.)				
		Single			Twin	
		K91, K161,K181	K241,K301,K321,K341		KT17,KT19	K582
Job No.	Description	Std.	Std.	Q♣	Std. & Q♣	Std. & Q♣
	Major Repairs					
4000	Engine R & R	1.0	1.0	1.5	2.5	3.5
4001	Generator Set R & R – Motor Home	2.0	2.0	2.0	2.0	2.0
4002	Engine R & R from Generator Set	1.0	1.0	1.0	2.0	2.5
4010	Short Block Replacement	3.0✧	3.0	3.2	3.0	5.0
4011	Miniblock Replacement	3.5✧	3.5	3.7	–	–
4012	Major Overhaul (Includes Valve Service)	5.0	5.0	5.5	6.0	8.0
4013	Minor Overhaul (Excludes Valve Service)	4.0	4.0	4.2	5.0	6.5
4014	Bare Block	4.0☆	–	–	–	7.0
4015	Connecting Rod	2.0	2.0	2.2	5.0	3.5
4016	Piston and/or Rings	2.0	2.0	2.2	3.0	3.5
	Crankshaft					
4020	Crankshaft & Main Bearing R & R	3.0	3.0	3.2	5.0	3.0
4021	Crankshaft – PTO Seal	0.5	0.5	0.5	0.8	0.8
4022	Crankshaft – Flywheel Seal	1.5	1.5	1.7	1.5	2.0
4023	Crankshaft & Connecting Rod	3.0	3.0	3.2	5.0	3.5
4024	Balance Gears – R & R	–	3.0	3.2	–	–
	Camshaft & Valves					
4029	Valve R & R (No Grinding) (Each Cylinder)	1.0	1.0	1.2	1.0	1.5
4030	Valve Tappet Adjustment	1.0	0.5	0.6	1.0	1.0
4031	Valve Grinding (Each Cylinder)	1.2	1.2	1.4	1.2	1.7
4032	Valve Guide Replacement	0.5♠	0.5	0.7	0.8	0.8
4033	Valve Spring Replacement	1.0	1.0	1.2	1.0	1.5
4034	Valve Cover Gasket and/or Breather	0.5	0.5	0.5	0.6	0.5
4035	Camshaft R & R	3.0	3.2	3.4	4.5	3.0
	Ignition					
4040	Ignition Timing	0.3	0.3	0.3	0.5	0.5
4041	Points and/or Condenser – Replace & Adjust	0.5	0.5	0.5	0.5	0.5
4042	Shipping Damaged Spark Plug – Replace & Adjust	0.2	0.2	0.2	0.2	0.2
4043	Spark Plug Wire – Replace (Battery Ignition)	0.2	0.2	0.2	0.2	0.2
4044	Spark Plug Wire – Replace (Magneto Ignition)	1.0	1.0	1.0	–	–
4045	Ignition Coil – Replace	0.3	0.3	0.3	0.3	0.4
4046	Magneto Coil – Test & Replace (Includes Flywheel R & R)	1.0	1.0	1.0	–	–
4047	Flywheel R & R	1.0	1.0	1.0	1.0	1.0
	Charging					
4050	Regulator – Test & Replace	0.5	0.5	0.5	1.0	0.5
4051	Stator – Test & Replace (Includes Flywheel R & R)	1.0	1.0	1.0	1.5	1.5
	Starter					
4060	Retractable – R & R, Replace Rope & Spring	1.0	1.0	1.0	–	–
4061	Starting Motor – Bendix Type R & R	0.5	0.5	0.5	0.5	1.0
4063	Starter – Rebuild (Includes R & R)	1.0	1.0	1.0	1.0	1.0
4064	Starter Drive R & R	0.5	0.5	0.5	0.5	0.5
4065	Starter Solenoid R & R	0.5	0.5	0.5	0.5	0.5
	Carburetor & Air Intake					
4070	Carburetor R & R	0.5	0.5	0.5	0.5	0.5
4071	Carburetor – Rebuild (Includes R & R)	1.0	1.0	1.0	1.0	1.0
4072	Carburetor – Adjust	0.3	0.3	0.3	0.3	0.3
4073	Air Cleaner – Damage in Shipment	0.3	0.3	0.3	0.3	0.3
4074	Fuel Tank – R & R	0.3	0.3	0.3	–	–
4075	Fuel Pump – R & R	0.3	0.3	0.3	0.3	0.3
	Miscellaneous Repairs					
4080	Cylinder Head and/or Gasket – Replace/each	0.5	0.5	0.5	0.6	0.6
4081	Cylinder Head Retorque	0.3	0.3	0.3	0.7	0.7
4082	Shrouds only – R & R	0.2	0.2	0.4	0.5	0.5
4083	Oil Pan and/or Gasket – Replace	0.5	0.5	0.5	–	0.5
4084	Muffler – Replacement	0.3	0.3	0.3	0.3	0.3
4085	Governor – Adjustment	0.5	0.5	0.5	0.3	0.7
4086	Governor Replacement	3.0	3.0	3.7	4.3	1.5
4087	Oil Pump Replacement	–	–	–	2.0	3.0
4088	Crankshaft – Grinding (ENTER NET COST)	–	–	–	–	–
4089	Crankcase – Boring (ENTER NET COST)	–	–	–	–	–

✧K141,K161,K181 only

☆K91 only

♠Excludes K91.

♣Q refers to Quiet Package.

FORM NO.:	TP-2303-F
ISSUED:	12/86
REVISED:	4/04
MAILED:	5/04

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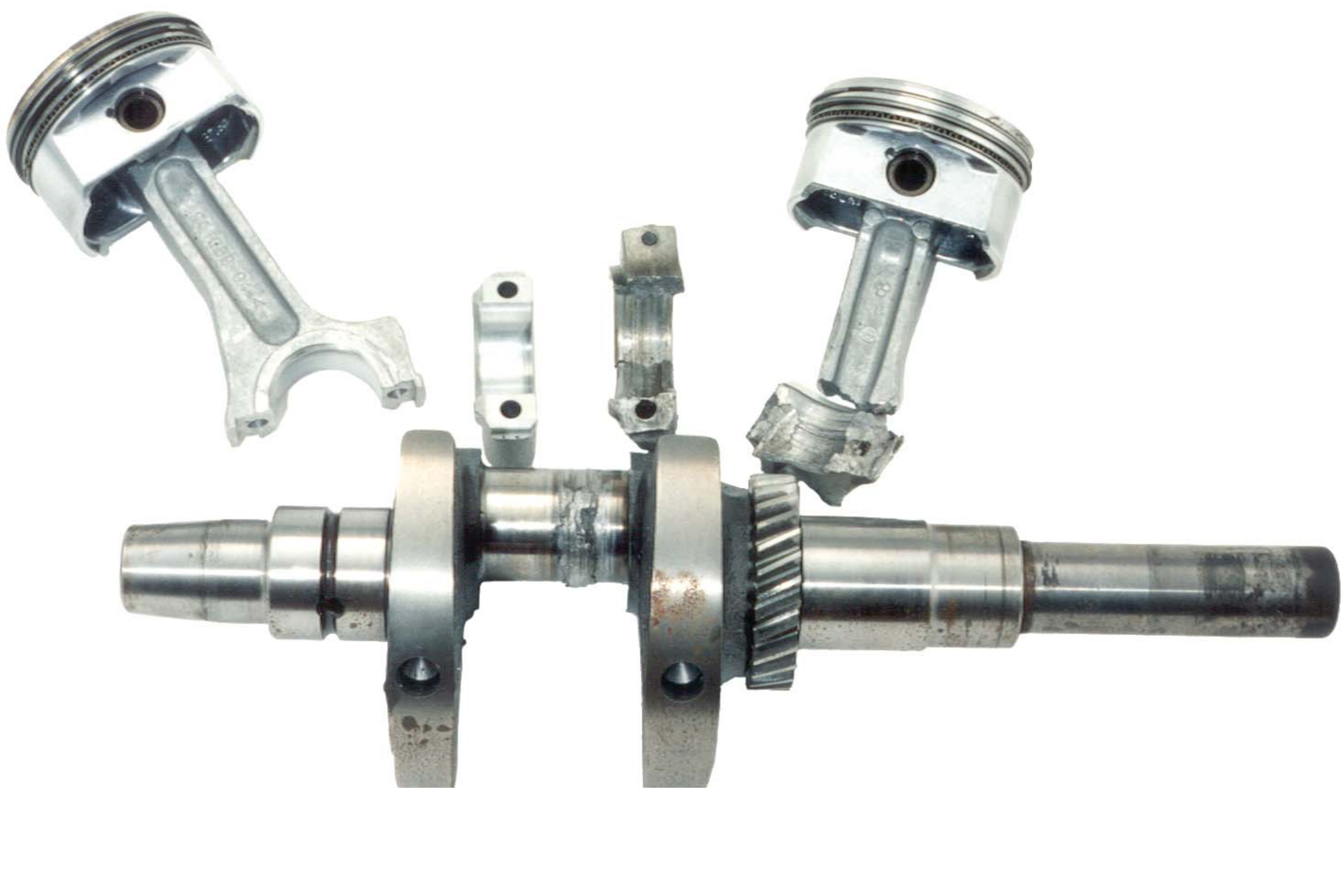
Failure Analysis Guidebook



Failure Analysis

I. Introduction

"It couldn't have run low on oil, I just changed it three weeks ago."

"How could it get dirt in it, I blow out the air cleaner every time I use it."

Everyone involved in the service of small engines has heard similar statements at one time or another. It's human nature to blame problems on "the machine", or on someone else. Therefore, it is important for every small engine serviceman to develop the ability to accurately diagnose the cause of an engine failure. If an incorrect analysis is made, the repair may not remedy the original cause, and a repeat failure may occur.

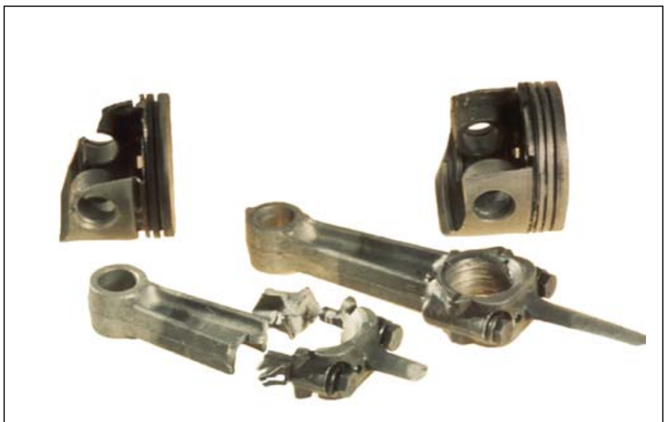


Figure 1.

Figure 1 shows two sets of parts from the same engine. The original piston failed from excessive clearance and slapping. The mechanic didn't measure the bore for wear and rebuilt the engine with standard parts. The bore wear was still present, so the new piston began slapping and broke up nearly identical to the original.

Some failures are the result of manufacturing defects, but it is a very small percentage compared to those which result from normal wear or customer neglect. You must be able to distinguish the difference to know if a failure qualifies for warranty consideration.

If the failure was due to neglect, you should provide an accurate explanation, so the customer refrains from making the same error again. The following information is provided to help you develop your expertise in analyzing engine failures.

II. Preliminary Examination

Any time an engine comes into your shop for service, you should begin by making an external examination. External conditions are often directly related to internal problems. Even if the engine is only in for routine maintenance or service, you may find indications that the customer is not providing adequate care for the engine and should be advised to change maintenance practices. If the engine has already failed, the condition of the exterior may provide valuable insight for assistance in analyzing an internal failure.

Check the following areas as part of your external examination.

A. Air Filtration

Figure 2.

Figure 2 – Make a thorough examination of the air cleaner. Remove the outer air cleaner cover and check it for damage or signs of impact.

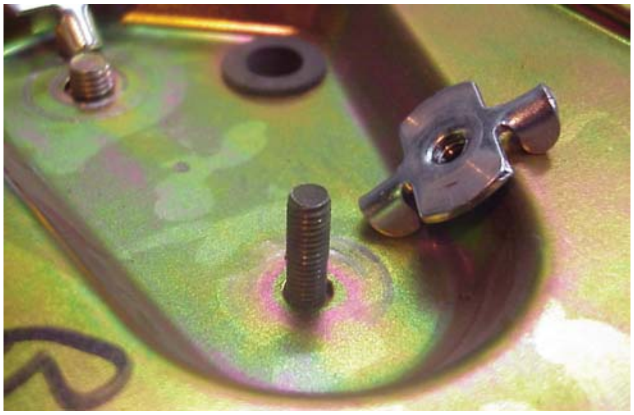


Figure 3.

Figure 3 – Most engines also have an inner cover on the air cleaner element, which provides backup protection in case the outer cover gets bumped or works loose. The inner cover may be a separate piece of stamped sheet metal, or it may be part of the element.

Three types of retainers are used on the element cover, a short rubber sleeve, a lock nut, or a wing nut. Check that the correct retainer(s) is/are there and tight. Remove the retainer(s) and look at the stud holes(s) in the element cover. If the stud holes(s) is/are wallowed out, it's an indication that the air cleaner components were loose at some time, and you're liable to find indications that dust or dirt has bypassed the system, as you continue your analysis.

Figure 4.

Figure 4 – Carefully remove the precleaner. Check it for tears or deterioration. Does it look like it's been serviced regularly, at the recommended 25 hour interval?

Figure 5.

Figure 5 – Remove the element cover, if separate otherwise remove the whole element. If there was no rubber sleeve on the outer portion of the stud, you should find one on the inner portion. Check its condition and look for an imprint or mark on the underside of the element cover to indicate that it was making contact and sealing.

Figure 6.

Figure 6 – Is the air cleaner element dirty, plugged, or damaged? Is it a genuine factory part?

Figure 7.

Figure 7 – Take a close look at the element sealing surfaces. Are there any dirt tracks across the sealing surface indicating leakage? Have the reinforcing wires punctured the rubber seal? If so, it indicates that the cover was overtightened. Protruding wires could allow leakage. This air cleaner element is obviously damaged. Note the crushed wire mesh. This is an example of an element that can not properly seal out dirt and debris. The lesson here is to check the sealing area of the paper element and the wire mesh for signs of damage due to over tightening, damage or abuse.

Figure 8.

Figure 8 – Check the element with a light for punctures in the paper filtering material. If you cannot see any light at the base of the creases, the filter should be replaced.

Figure 9.

Figure 9 – Check the inner portion of the air cleaner base plate and the carburetor throat for signs of dust or dirt. If any traces are found, recheck all of the air cleaner components to determine the source of dirt entry. Perhaps the breather hose was pulled loose from the base plate, allowing dirty entry through the hole.

B. Oil

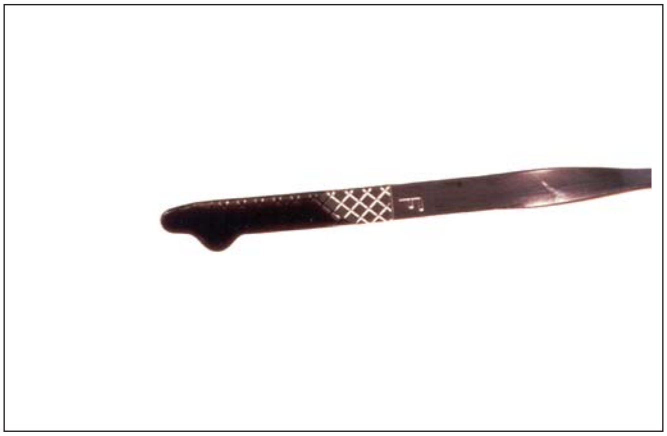


Figure 10.

Figure 10 – Pull the dipstick and check the oil. Look at the level of oil, but also note the color and consistency of the oil. Is it fresh, clean oil that was added after a failure? Or, perhaps, it's so thick and dirty it won't drip off the stick because it hasn't been changed in 150 or 200 hours. When you drain the oil, measure the amount that you drain out and examine it closely. Notice again the color and consistency. Does it have an abnormal smell? Do you see any metal chips or wear particles? Do you notice any sludge? If the engine has an oil filter, notice whether is a genuine factory part.

C. External Surfaces

Figure 11.

Figure 11 – Check the overall condition of the exterior. Is the outside relatively clean, or is there an accumulation of oil, dirt, chaff, etc.? Are there any visible oil leaks? Also check for any indication that the engine may have been disassembled or repaired previously.

D. Cooling System

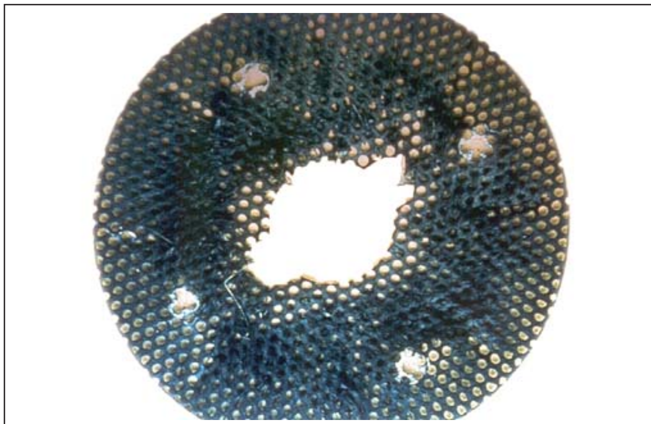


Figure 12.

Figure 12 – Is the grass screen plugged or restricted, possibly contributing to overheating?

Figure 13.

Figure 13 – What about the cooling fins? The engine needs adequate air flow across the cooling fins to dissipate heat.

E. Carburetor and Intake

Figure 14.

Figure 14 – Carefully examine the carburetor and the intake manifold. Is anything broken or loose? Is there dirt or debris in the manifold/intake area? Are the mounting gaskets in the right location and are they the right ones?

F. Governor Components

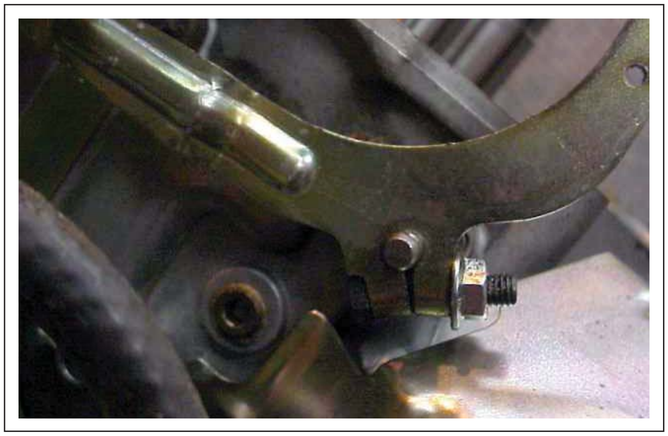


Figure 15.

Figure 15 – Check the external governor components and linkages. Are any of the pieces bent, broken, or missing? Have any non-factory modifications been made?

Figure 16.

Figure 16 – Operate the throttle control and check whether the mechanism can move freely through its normal range. Check the initial governor adjustment setting. Also note the position of the governor spring. Has it been moved?

G. Final Check
Finally, in addition to the air cleaner system which has already been checked, look for any other possible point(s) where dirt or contamination may have entered the engine.

The conditions found during your preliminary examination should be noted for future reference. The Engine Inspection Data Record, TP-2435, is available from Kohler Co. to record your findings (see sample at back of book).

If a major failure has occurred, this form should be filled out before your distributor representative arrives to make the warranty analysis inspection.

III. Disassembly

You are now ready to proceed with the disassembly and failure analysis inspection procedures. During disassembly, there are, again, specific areas that should have investigative attention.

A. Peripheral Parts

Figure 17.

Figure 17 – After the shrouds have been removed, check the cooling fins and cylinder block surfaces that were not visible earlier. Note any additional findings on the Engine Inspection Data Record.

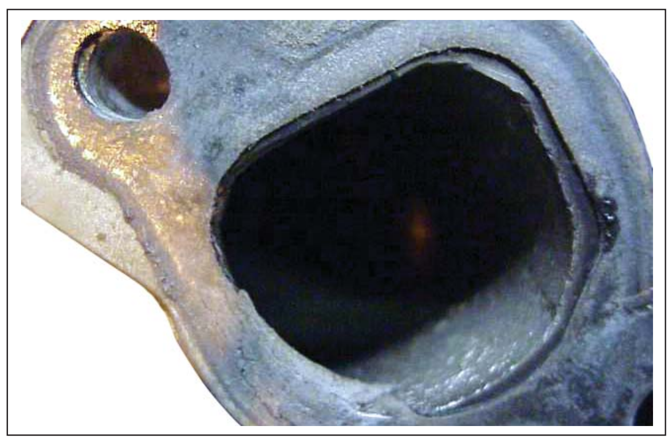


Figure 18.

Figure 18 – After removing the carburetor, check the throat of the intake manifold or intake port for traces of dust, dirt, or other contamination.

B. Cylinder Head

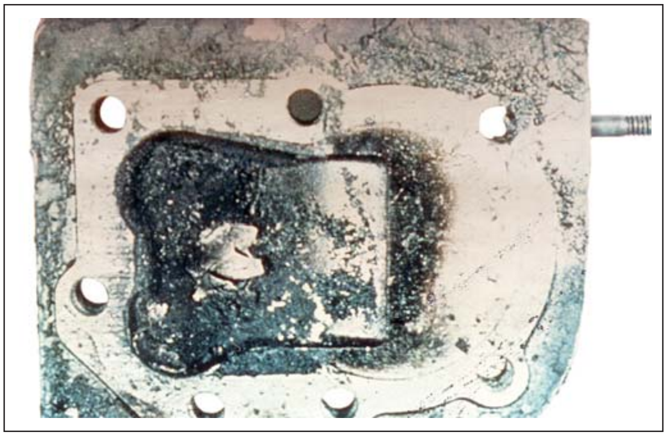


Figure 19.

Figure 19 – After removal of the spark plug(s) and cylinder head(s), check the combustion deposits, as they are often a good indicator of operating conditions. This head has heavy black oil or gummy-looking deposits, indicating that the engine was burning oil, usually from internal wear. This particular engine had so much oil entering the combustion chamber that it was starting to flush out the combustion deposits. And the head hadn't been cleaned for so long that the deposits completely cover the tip of the spark plug.

Figure 20.

Figure 20 – Here is another head with similar oily, glossy-looking deposits. A build-up of crankcase pressure (breather plugged or inoperative), forcing oil past the rings, could cause this also.

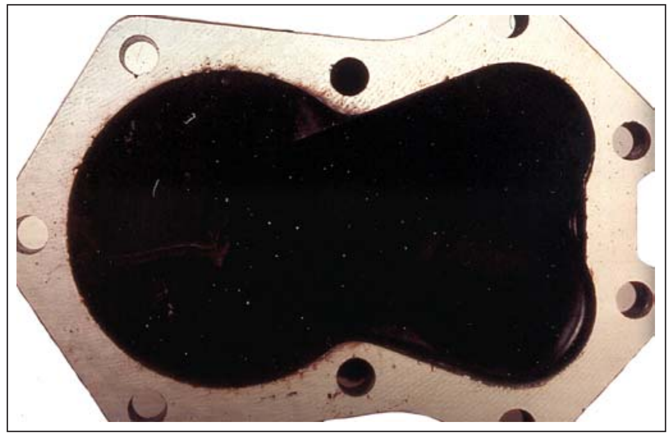


Figure 21.

Figure 21 – Soft, black, sooty deposits result from incomplete combustion. They could be due to overrich carburetor settings, a blocked air filter, or retarded timing.

Figure 22.

Figure 22 - Hard, crusty, mottled white deposits result from high combustion chamber temperatures. They could be from lean carburetion, an intake air leak, over-advanced timing, or poor quality gasoline. Deposits of this type will often be accompanied by a blown head gasket. The high temperatures and pressures that cause the white deposits also cause the head to distort and push the hot exhaust gases past the gasket. If the engine is operated with the blown gasket, the escaping hot gases can act like a torch and burn a slot through the gasket and sometimes even through the head.

C. Oil Sump

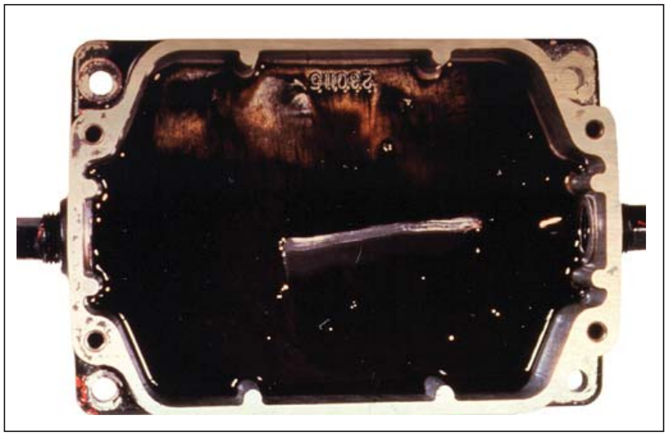


Figure 23.

Figure 23 – Check the bottom of the oil sump. A layer of sludge in the bottom of the engine indicates that contamination was entering the engine, the oil was not being changed at the recommended interval, or incorrect oil was used.

D. Valves

The valves can be very good indicators of various operating conditions. They should be closely examined as part of your failure analysis procedure.

The symptoms associated with valve problems include the following: hard starting, high fuel consumption, poor compression and loss of power, or the engine will pop and stall after a period of running. The most common problems related to valves are burning, sticking and valve erosion.

To help distinguish good from bad, we have included some examples of both.

Figure 24.

Figure 24 – This intake valve was removed from an engine in good operating condition. Notice the bright, uniform sealing ring around the face. The coke deposits on the underside of the head and upper stem are normal for an engine with some running time on it.

Figure 25.

Figure 25 – This engine was also in satisfactory running condition. However, you will notice that the “coking” is significantly worse. Possible contributing factors are: prolonged periods of idling, continuous duty at light load, “lugging” the engine during operation, running with a restricted air cleaner, or valve stem and guide wear.

The deposits are not yet interfering with normal operation, but they could if allowed to accumulate much more.

Figure 26.

Figure 26 – This is an exhaust valve from an engine in good operating condition. Again, note a good sealing ring on the face. Relatively light, brownish deposits indicate good operating conditions. An engine running under proper conditions will usually have light brown, brown, or gray deposits.

Figure 27.

Figure 27 – The white deposits, seen here, indicate very high combustion temperatures, usually due to a lean fuel mixture. The engine had only run for a short time, so the faces have not yet started to burn, but you will note that the sealing ring has already started to deteriorate.

Figure 28.

Figure 28 – Continued operation with high combustion temperatures will result in more severe burning and deterioration of the valve face.

Figure 29.

Figure 29 – Valve burning will also occur if there are conditions present which prevent the valve from closing or sealing properly. Here we see deposit accumulation around the entire circumference of the face. This would normally indicate that the valve was not closing completely. Perhaps the tappet clearance was incorrectly set, or combustion deposits may have flaked loose in the head and lodged between the valve and seat. Because the valve is not sealing, it will start to burn with continued operation.

Figure 30.

Figure 30 – When the exhaust valve is burned, or not sealing, the fuel burn is no longer contained within the combustion chamber. Each time the engine fires, a burst of flame passes the valve. As the face continues to burn and deteriorate, the combustion leakage begins to act like a torch. The valve material on the underside of the head and neck begins to burn away, a condition referred to as valve erosion.

Figure 31.

Figure 31 – If the initial valve burning was due to extreme combustion temperatures (lean mixture, etc.), the blistered white deposits may also show up in the area of erosion.

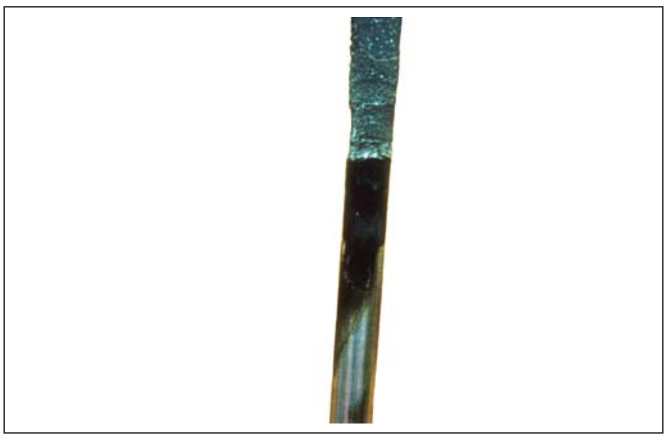


Figure 32.

Figure 32 – Another, fairly common valve-related problem is valve sticking. It is usually caused by an accumulation of burned oil deposits on the valve stem and in the guide.

The customer will usually complain that the engine runs anywhere from 15 to 90 minutes, then loses power or "pops" out the exhaust and stalls. It normally will not restart until the engine cools for 10-15 minutes and a metallic snap is heard.

The burned oil deposits normally responsible for valve sticking are due to elevated temperatures in the valve guide area. The problem will usually show up during hot weather, especially on an engine that doesn't get adequate maintenance.

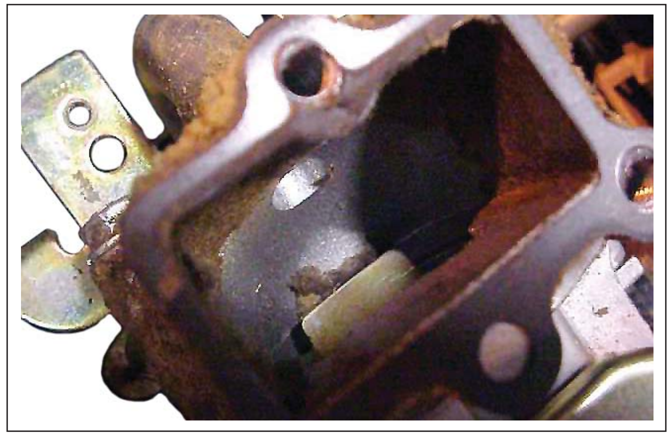


Figure 33.

Figure 33 – If a valve stem shows signs of abrasive material or scoring, check the carburetor inlet and air cleaner base for signs of dirt bypassing the air filter or precleaner.

Figure 34.

Figure 34 – If your preliminary examination of the engine indicated the possibility of dust or dirt entry, check the stem of the intake valve(s) for further confirmation. The valve stems should appear shiny like the one on the left. If contamination has been entering through the air intake, the stems will have dull wear patterns where they travel in the guides.

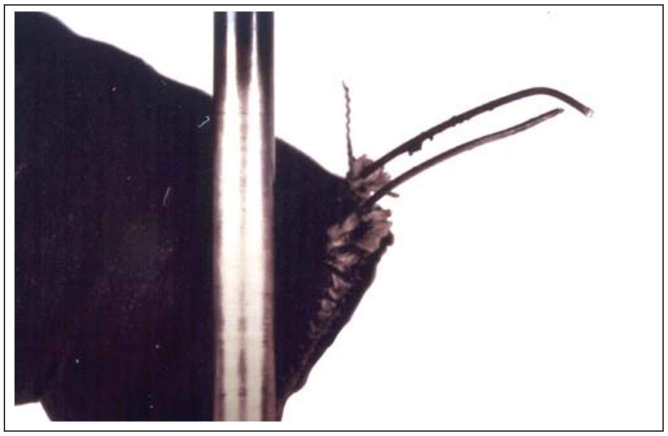


Figure 35.

Figure 35 – In this example, the dirt entry was due to a leaking remote air filtration system. Again notice the “buffed” appearance of the valve stem.

Also notice the air cleaner hose which was used. Wire reinforced hose should never be used with a remote air cleaner. The wire does not compress under the clamps, preventing a good seal, and allowing unfiltered air to enter at the joints.

E. Major Components
The cylinder/crankcase, crankshaft, connecting rod, and piston assembly are usually considered to be the major components of an engine. They are the parts that confine the energy of combustion and transmit the power of that energy to the piece of equipment to perform work. Because of the tremendous forces and stresses they must withstand, they are the components with the most critical running tolerances. They are also the components most subject to failure.

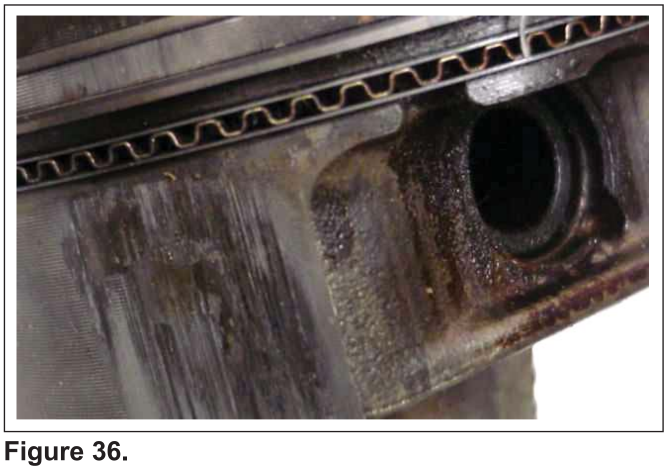


Figure 36.

Figure 36 – Be careful when disassembling the major components, so you do not disturb or destroy any critical evidence.

Leave the parts in their original state as much as possible, until the failure analysis procedure has been completed. Do not clean anything unless it is necessary to make an accurate inspection.

IV. Analyzing the Failure

A. Pistons and Rings

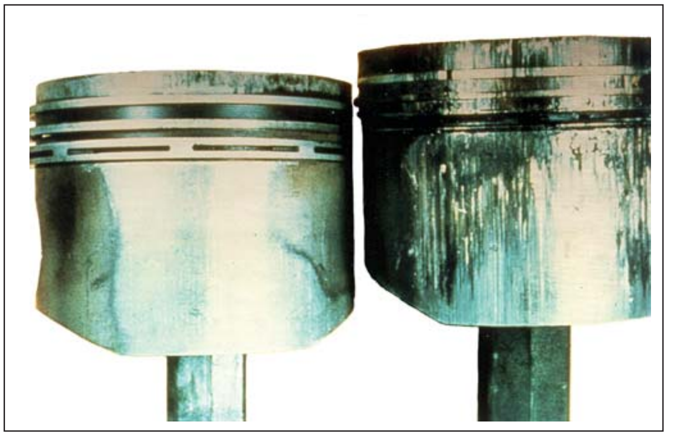


Figure 37.

Figure 37 – Problems relating to the piston and rings will usually fall into one of two categories, excessive wear or piston seizure.

Figure 38.

Figure 38 – Excessive wear can often be detected visually, even before any measurements are taken. From normal operation, the wear pattern on the thrust face of a piston will cover about 20-40% of the face. If it cover 50% or more, with visible vertical scratches, you know there has been contamination between the piston and cylinder wall causing excessive wear.

The erosion at the very top edge of the piston is also due to the wear. As the rings wear, oil consumption increases resulting in more combustion deposits, and a carbon ridge forms at the top of the cylinder.

In the area near the exhaust valve, the carbon becomes very hard and abrasive from the exhaust temperatures. When the piston repeatedly hits those hard deposits, the material is gradually eaten away. The newer Mahle pistons, used in most Kohler engines today, have the top land machined to a smaller diameter to allow more clearance and help prevent this type of damage.

Figure 39.

Figure 39 – Damage from contamination entering an engine can occur over an extended period of time with very slight leakage, or it can be quite rapid, if a significant amount of dirt is entering. This damage occurred in just 15 hours of running from ingesting about 1/4 teaspoon of dust per hour.

If a customer punctured their air cleaner element by using compressed air, or assembled the air cleaner incorrectly, that the element was not sealing, then ran the engine for a week or two before discovering the error, the engine could already be worn beyond acceptable limits.

Figure 40.

Figure 40 – If the engine is running hot (blocked screen or fins) and ingesting dirt at the same time, the wear will occur even more rapidly. This Command engine was completely worn out after just 125 hours of operation. The oil ring rails are so badly worn that the expander was rubbing the cylinder walls.

Figure 41.

Figure 41 – On the other hand, heavy ring wear, with little or no bore wear, indicates that high operating temperatures were present, but little or no dirt.

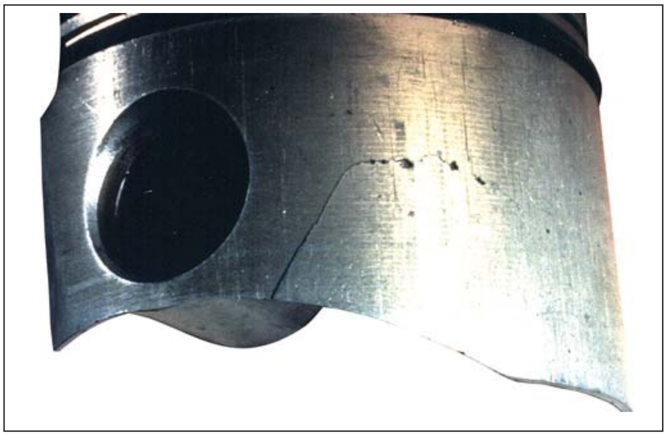


Figure 42.

Figure 42 – If a customer ignores the first signs of wear (oil consumption and blue exhaust smoke) and continues to run the engine, the wear will progress to the point that the piston begins to “slap” because of the excessive running clearance. The piston slap puts increased stress on the piston skirts and they can begin to crack.

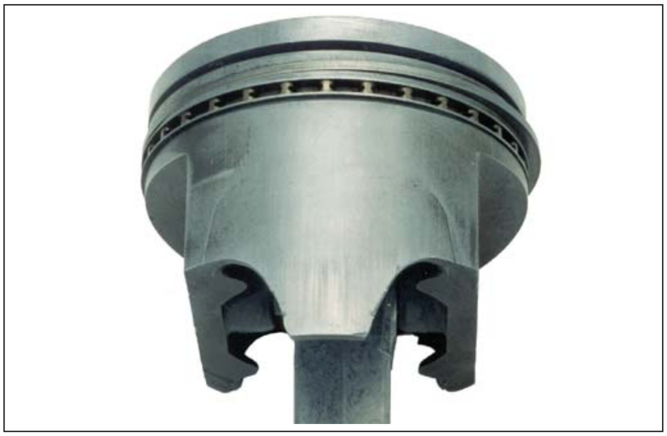


Figure 43.

Figure 43 – With continued operation, the cracks will progress across the thrust face and/or up toward the oil ring groove.

Figure 44.

Figure 44 – In some cases, just the lower portion of the skirt will break off.

Figure 45.

Figure 45 – In other cases the whole piston will break up. The customer will not be able to ignore it any longer.

Figure 46.

Figure 46 – A customer that doesn't maintain a twin cylinder engine ends up with double trouble.

Figure 47.

Figure 47 – This engine ran for only 6 hours following a rebuild. The piston ring end gaps go as high as .042 in., and the crankpin was .007 in. undersize.

Always scrub the cylinder with hot water, detergent, and a brush after it has been bored or honed. Use sufficient detergent to provide good sudsing action. This way, you can be certain that the machining oil is broken down to allow complete removal of the grit particles from the pores of the iron.

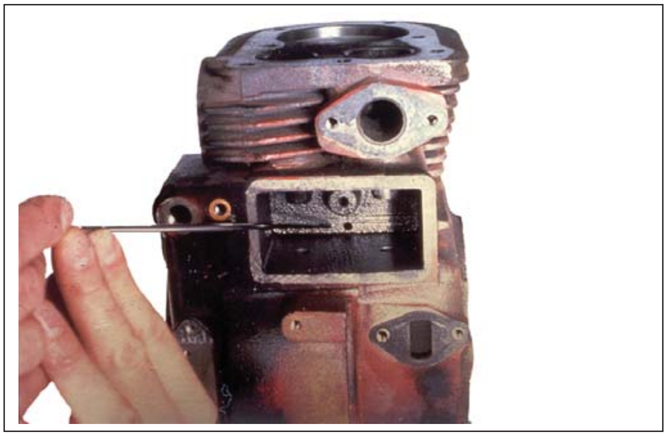


Figure 48.

Figure 48 – On a single cylinder block, also be certain to clean and flush out the oil drain hole which goes from the valve chamber into the cylinder.

Figure 49.

Figure 49 – Piston seizure is also visually obvious, but it can be a little more difficult to analyze. There are a number of possible causes, but the appearance doesn't vary much from one to another. Possible causes include overheating from insufficient cooling air, lack of lubrication, insufficient running clearance, oil additives, and contamination or foreign material in the engine. This is one instance where your preliminary examination may be very helpful. Did you find dirty, thick oxidized oil in the engine? Was the cooling system restricted?

You may also find other indicators on other portions of the seized piston.

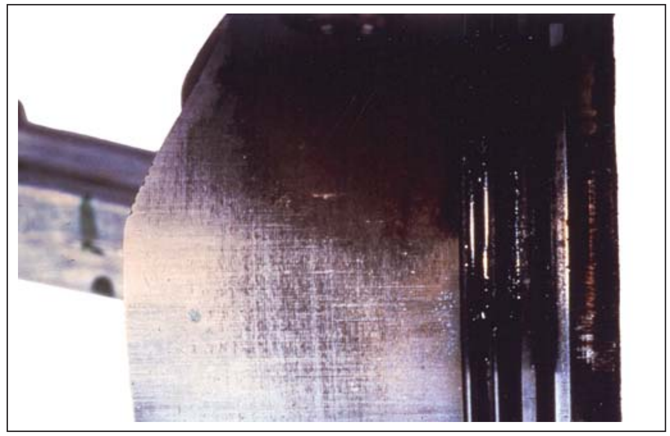


Figure 50.

Figure 50 – The scoring on a seized piston is sometimes just on the primary thrust face. Look at the opposite thrust face and the sides for other possible indicators.

Figure 51.

Figure 51 – This piston shows evidence of overheating. Notice the dark brown deposits as well as the blackened area near the wrist pin. This is severely overheated oil starting to bake. Your next challenge would be to see what is causing this condition.

Figure 52.

Figure 52 – This engine had high combustion temperatures and restricted cooling, resulting in very black, scorched deposits.

Figure 53.

Figure 53 – Severe oxidation or use of an oil additive can cause a complete breakdown of the oil. The deposits will appear to be a cross between axle grease and tar.

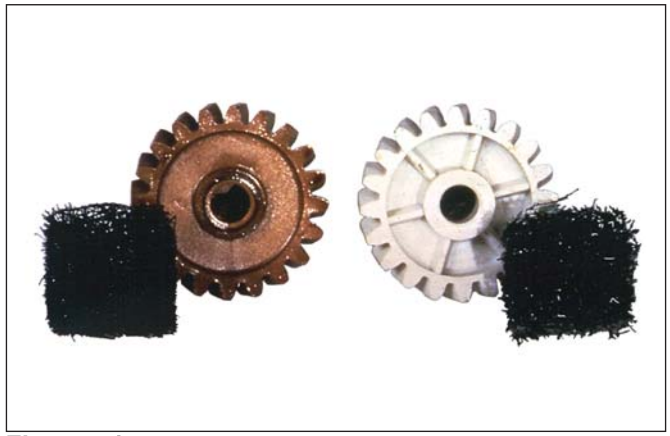


Figure 54.

Figure 54 – If the piston has signs of overheating and/or oxidized oil, look at the governor gear and breather filter for further confirmation. The governor gear takes on a dark orange or rust color when exposed to overheated oil. The breather filter will also be discolored with burned oil deposits. In severe cases it may be so brittle that it crumbles.

Figure 55.

Figure 55 – Seizures due to insufficient running clearance will usually result in scoring without any other signs. The scoring may show up on both thrust faces, heavier on the primary face (toward the valves).

B. Connecting Rods

Connecting rod failures will provide some of the greatest challenges to your failure analysis expertise. Sometimes the indicators will be pretty clear. However, in other cases, they may be difficult to spot, or there may be two or three indicators that seem to contradict each other. The rod may be broken in such small pieces that it's difficult to find any failure indicators.

Your preliminary examination of the engine may provide some valuable assistance where the rod failure indicators are elusive or unclear.

Figure 56.

Figure 56 – There are many different failure modes on connecting rods, but some of them are more common or prevalent than others. A few years ago, a task force at Kohler Co. analyzed more than 400 connecting rod failures. When they compiled their data, nearly 75% of the failures they had looked at were similar to the rod in this photo, so this could be considered a "typical" connecting rod failure.

The connecting rod had seized onto the crankshaft, melting and searing the aluminum on the bearing surface in the process. The exterior surfaces are dark, with burned oil deposits around the journal area. Often, the burned oil deposits will extend part way up the beam and down onto the dipper (if it's a splash-lube rod). The rod may be fractured, possibly a single break, or several pieces, Sometimes, on twin cylinder engines, the engine keeps on running on the opposite cylinder after one rod has failed, and the broken rod gets smashed into many tiny fragments. Those are probably the most difficult to analyze, because the pieces are so small it's difficult to find and identify any good failure indicators.

Figure 57.

Figure 57 – All of these rods failed by seizing onto the crankpin. While there are many similarities, if you look closely, there are also some subtle differences.

To correctly analyze rod failures, you will need to identify both. The similarities will usually help you determine a general failure category (lack of oil, manufacturing defect, etc.). The differences will help you distinguish one from another, and often provide clues to the circumstances or conditions that caused that particular failure.

Where, then, should we look to determine the cause of failure? Actually there are four areas that should be scrutinized before a decision is made.

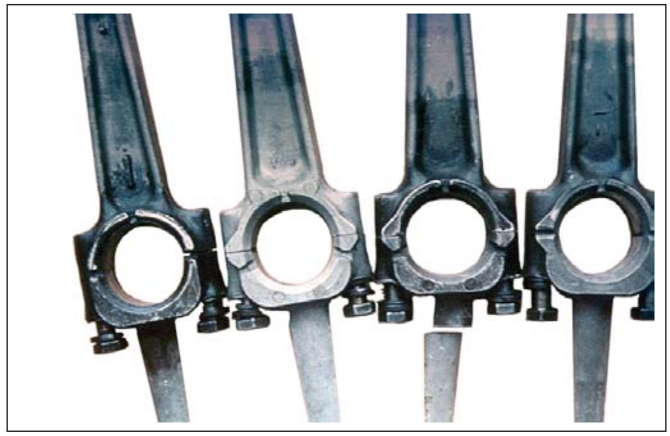


Figure 58.

Figure 58 – The first area to examine is the journal area and the dipper (if it has one). Did the rod seize, causing the aluminum on the bearing surface to smear and transfer? Is the outside of the journal area discolored/ darkened? Are there burned oil deposits present? Do the burned oil deposits extend down onto the dipper? What is the condition of the dipper (intact, broken, nicked or scraped, discolored)?

The first rod on the left is very similar to Figure 56. It seized on the crank and it has burned oil deposits on the outside of the journal. A seizure results when there is inadequate lubrication between the crankshaft and the rod. The burned oil deposits indicate there was some oil present, but it wasn't providing adequate lubrication. The engine was probably run low on oil.

The second rod had some running time, but it never had failure or problem. It is included in the photograph to help you distinguish color variations.

The third rod has a broken dipper. The lighter color of the broken segment indicates that the break occurred before the rod seized. In fact, the broken dipper caused the failure. If the color had been the same on both sides of the break, it would have indicated that the dipper broke after the seizure and the cause of failure would have to be found elsewhere.

The last rod came from an engine that was started with no oil. The bearing surface is smeared, and the rod is darkened from the heat of the seizure, but there are no burned oil deposits because there was no oil present.

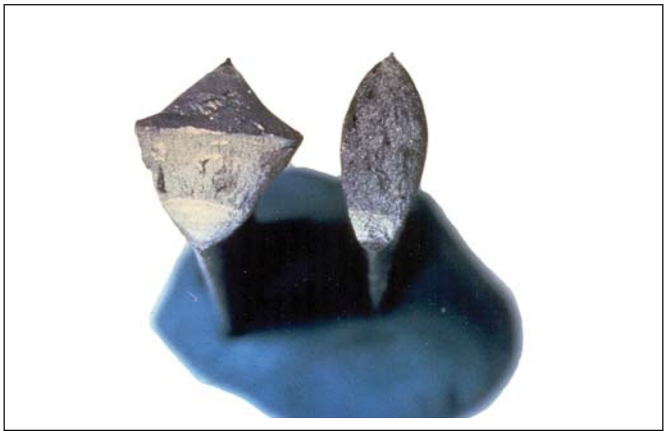


Figure 59.

Figure 59 – If the dipper is broken, look closely at the break surface. Is it a tensile break or a fatigue break?

Figure 60.

Figure 60 – A tensile break results from a single sharp blow that breaks off the dipper. The dipper will have a nick or scrape where it was hit, and the break surface will be quite rough, because the metal has been torn apart. You might also notice a "feather" pattern, which can indicate the direction of the breaking force.

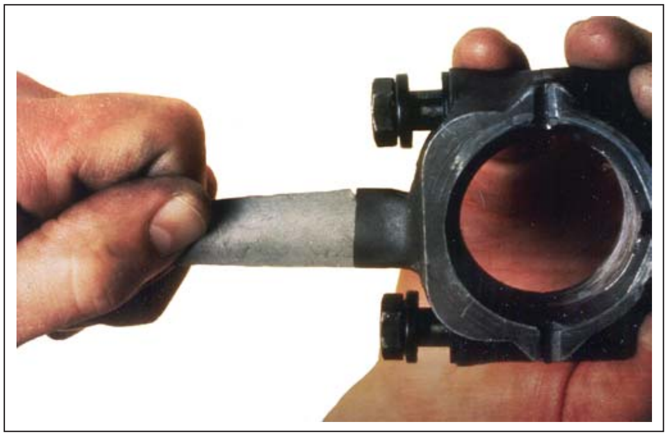


Figure 61.

Figure 61 – A fatigue break usually results from damage done prior to, or during assembly. If the rod is dropped on the dipper, or the dipper is bumped against the workbench, a small stress crack can be created in the aluminum. The forces of operation, along with repeated heating and cooling, will cause increased metal fatigue around the crack. The crack will spread until the dipper finally separates and drops into the oil pan.

Figure 62.

Figure 62 – After the dipper drops off, the rod will seize because the oil is no longer being circulated to the bearing surface. The high friction temperatures generated during seizure cause the oil to burn around the journal area and down to the break line. A definite color variation will be obvious at the break line.

Figure 63.

Figure 63 – The break surface of a fatigue break will be smoother than a tensile break. Often the fatigue process leaves semi-circular markings, called beach marks, on the break surface. The center of the markings is the point at which the break originated. Here the dipper was bumped or damaged from the side.

Figure 64.

Figure 64 – Examination of this break surface confirms that it is a fatigue break, and also reveals the cause of the break, a casting defect.

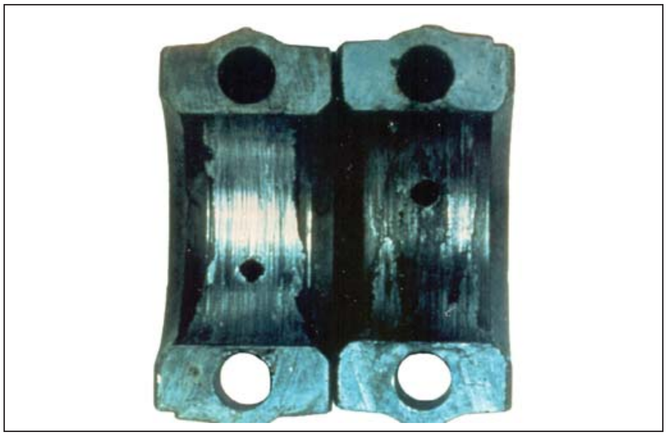


Figure 65.

Figure 65 – The second area of examination is the bearing surface of the rod. The bearing surface will often be smeared, but it can still reveal clues about the conditions at the time of failure. These two rod caps are a good example. Notice the difference in color.

The cap on the right has streaks of burned oil blended with the smeared aluminum, indicating that there was some oil present, but not enough for adequate lubrication. It's from an engine that was run low on oil. The cap on the left has only the bright, smeared aluminum, no traces of oil. It was from an engine started without oil.

Figure 66.

Figure 66 – What led up to this failure? If you guessed it was another engine started without oil, you're right.

Figure 67.

Figure 67 – Here you see shiny, smeared aluminum in the center of the bearing surface, and no discoloration on the outer surfaces. The failure was due to insufficient running clearance between the rod and crankshaft. The rod had been overtightened and the bearing area collapsed, squeezing out the film of lubricating oil. The engine had oil in it, which cooled the outer surfaces, but it couldn't reach the center of the bearing surface.

Figure 68.

Figure 68 – The aluminum in a forged connecting rod appears brighter than a die cast rod. This is a forged rod that failed from running without oil. The smeared aluminum is very bright with no burned oil deposits. Because a forging is stronger than a die casting, you may also notice some unusual twisting or distortion.

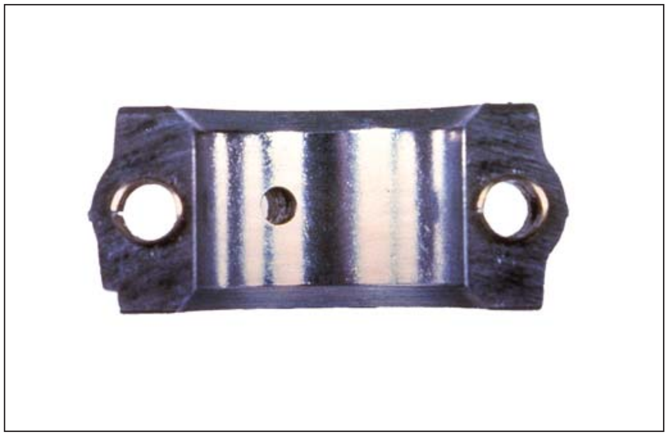


Figure 69.

Figure 69 – If a connecting rod has not seized, the bearing surface can also be a wear indicator.

The final finishing operation on a connecting rod leaves a textured, but highly polished surface finish. If there is dirt in an engine, it combines with the oil and works like a buffing compound on the bearing surface. The highest loading occurs at the top and bottom of the stroke, so the top and bottom of the journal will show wear first.

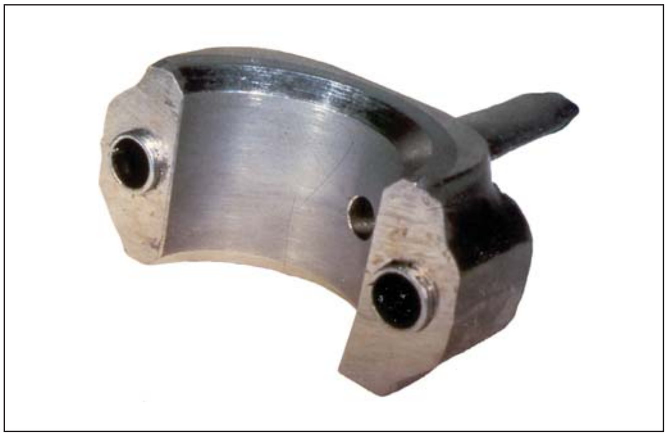


Figure 70.

Figure 70 – This rod is from an engine that ran for 15 hours with dirt in the crankcase. The original surface finish has been worn off leaving a dull, satin appearance.

Figure 71.

Figure 71 – If there is a heavy concentration of dirt, or the particles are large and abrasive (honing grit), you may see a “dirt” trail around the center of the bearing surface. The dirt entering through the oil hole gets pounded into the surface of the aluminum, leaving a trail around the bearing, in line with the hole.

Figure 72.

Figure 72 – This connecting rod came from the engine mentioned earlier (Figure 47) where the block was not cleaned properly after honing. Again note the worn bearing surface with the abrasive trail in line with the oil hole.

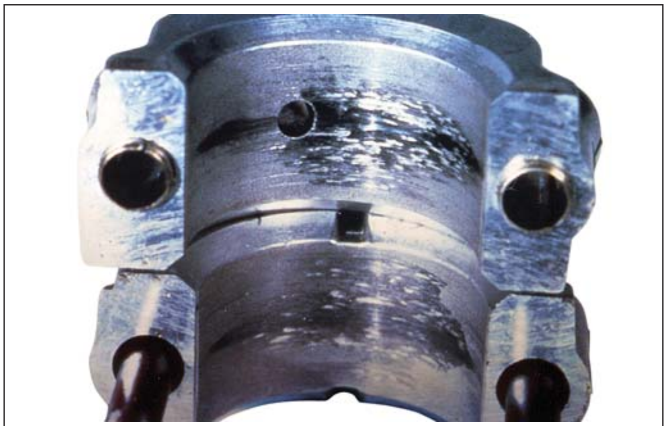


Figure 73.

Figure 73 – This rod came from another engine that was not cleaned properly prior to rebuilding. After only 6 hours of running, the crankpin was worn .008 in. undersize. The rod had started pounding because of the excessive running clearance, causing the aluminum to begin smearing. The customer became alarmed when the engine started knocking and losing speed. Within one more hour of running, a total seizure would have occurred.

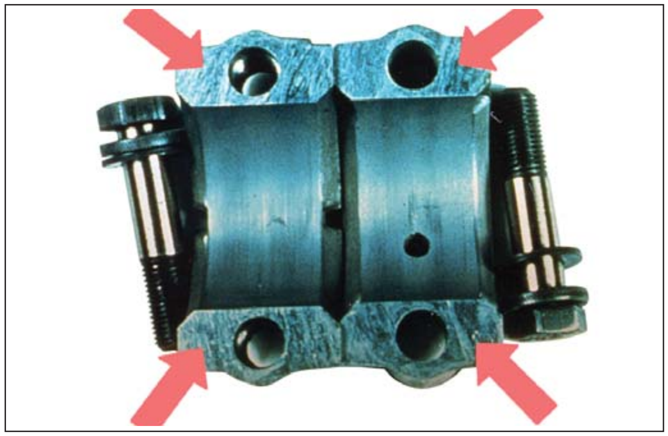


Figure 74.

Figure 74 – The mating surfaces of the connecting rod are the third area that should be inspected.

The machining marks that you see here are normal. They are made by the saw blade when the rod is out.

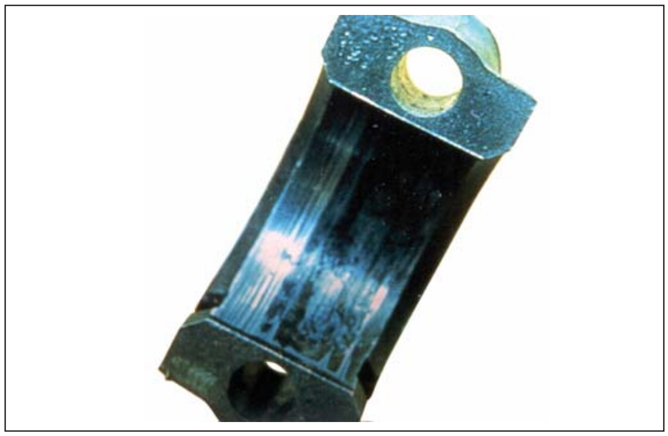


Figure 75.

Figure 75 – Here you cannot see any of the saw blade markings. Instead the mating surface has a hammered or peened appearance. The rod bolts were not tightened properly and the peening results from the two sections of the rod pounding together as the bolts backed out.

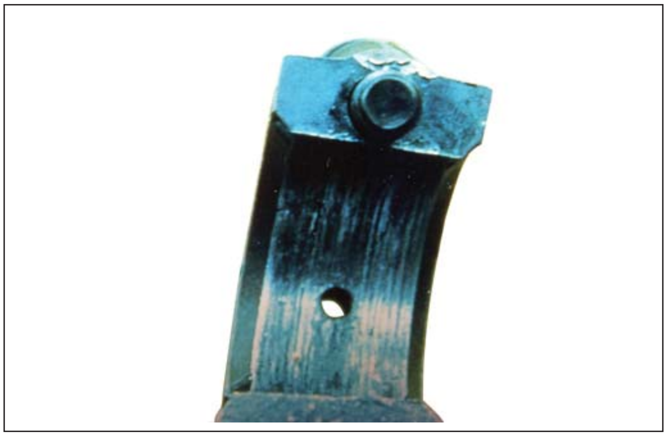


Figure 76.

Figure 76 – Here is another example of undertightening. In this case, the bolts were just loose enough for the rod sections to work against each other, but not loose enough for them to hammer. The result is a dull gray finish on the mating surface known as “fretting.” If magnified, this “fretting” would look like the “peening” you saw in the last slide. This condition will not be seen on Posi-Lock rods.

Figure 77.

Figure 77 – This piece has just a small peened area near the outer edge of the mating surface. The looseness here resulted from the high temperatures generated by the seizure. The bolts had been tightened properly and only began to yield when the rod started to seize. This type of peening is secondary. The cause of the failure was insufficient lubrication.

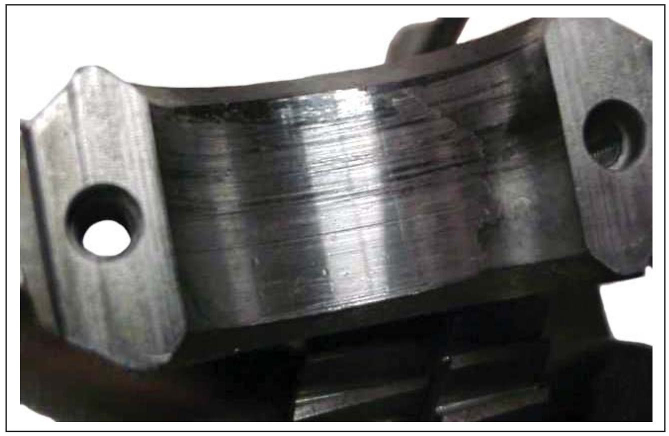


Figure 78.

Figure 78 – This rod cap shows signs of scoring and aluminum smearing. If you look closely it has a double layer of aluminum on the right hand side. This engine was started with no oil; it seized and was freed up. It was restarted and shortly after it seized again because the aluminum transfer from the first seizure left insufficient running clearance. The lesson here is make sure there is oil in the engine before starting.

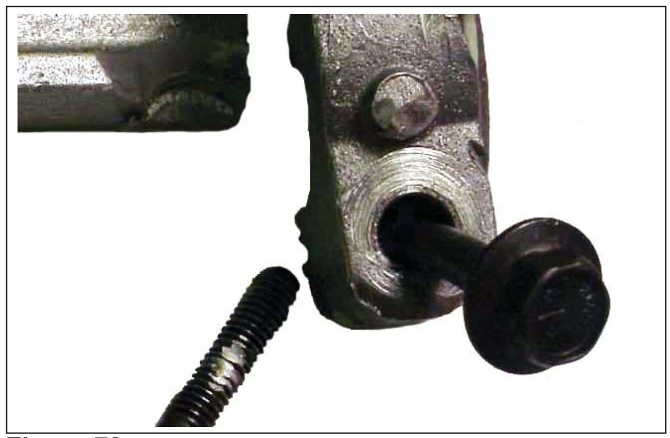


Figure 79.

Figure 79 – This is a shot of a rod bolt that was loose. This came early within its life cycle. Notice the elongation of the hole where the bolt comes through. You can also notice where the bolt wore a groove into the rod cap.

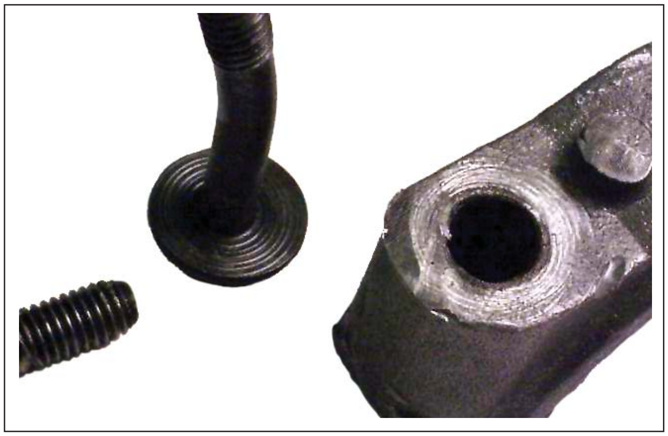


Figure 80.

Figure 80 – This is a shot of the rod you saw in Figure 79. Again notice the way the bolt is elongated and how there is no sign of heat or burned oil.

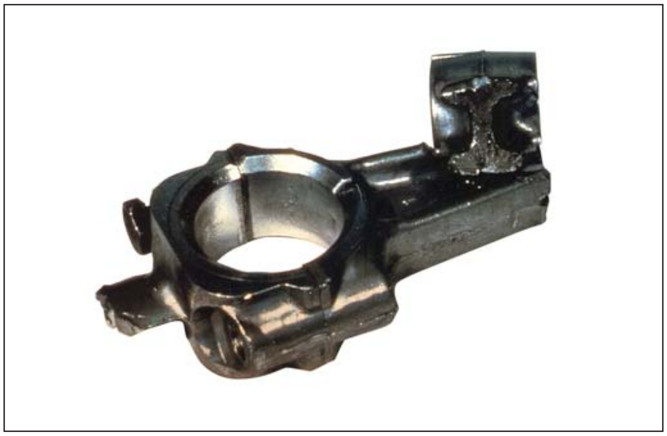


Figure 81.

Figure 81 – This connecting rod broke in the beam, but has no other visible damage and did not seize. When we look at the break surface, there is no sign of fatigue or a casting defect, just a tensile break of a good casting. This failure was caused by engine overspeed.

C. Combination Failures

Many failures involve more than one engine component. When two or more parts have failed, or been damaged during failure, analysis can be more difficult.

In those situations, look at each individual component to see if it actually failed, and why, or if it just received secondary damage. Then look at the parts collectively. If more than one part failed, try to develop a logical sequence. Weigh all of the evidence before making a decision.

Figure 82.

Figure 82 – Our first example includes a broken connecting rod and a broken governor gear. The rod bearing surface looks like it ran without oil. Notice, however, that the dipper is broken, and not discolored. The dipper broke first and caused the rod to seize. But the real culprit here is the governor gear. One of the roll pins backed out and the flyweight separated from the gear, breaking the gear in the process. The flyweight dropped into the oil pan and knocked the dipper off the rod.

If we had looked at only the rod bearing, we may have concluded that the engine was run without oil, and we would have been dead wrong.

Study all of the evidence and be certain that your decision incorporates everything you see.

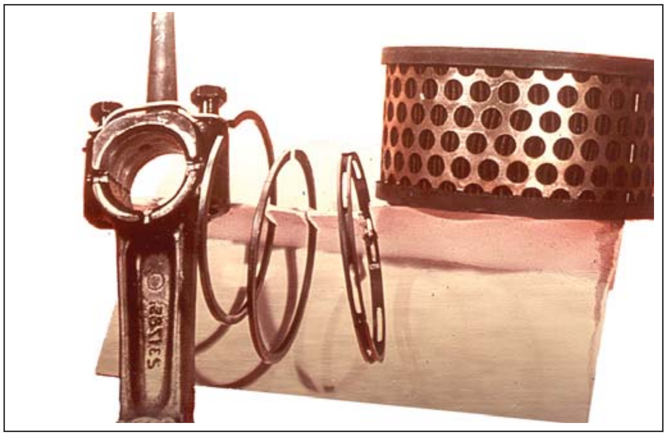


Figure 83.

Figure 83 – A high percentage of small engine failures result from customer neglect. Here you can see the dirty air cleaner, considerable wear on the piston rings, and traces of dirty, burned oil on the connecting rod. There is a color change line on the dipper, but it was only about 3/8 inch from the tip, so the oil level was well below the "low" mark on the dipstick at the time of failure.

Figure 84.

Figure 84 – This rod shows signs of aluminum transfer with burned oil deposits. The rod seized from inadequate lubrication. As it locked up on the crankshaft, the turning force of the flywheel and crankshaft caused the connecting rod to snap in the beam, and tried to pull the rod apart at the fastener joint. The aluminum thread transferred to the rod bolt is a secondary occurrence and not a loose rod bolt.

Figure 85.

Figure 85 – This rod broke toward the bottom. Notice the slight smear of aluminum and blackened oil. The piston shows signs of overheating. This could have been caused by an improper honing/oversize procedure, where the piston to bore clearance was too tight, causing the stress and failure of the connecting rod. Notice that the rod bolt is sheared.

Figure 86.

Figure 86 – This connecting rod shows multiple breaks. The break in the middle of the beam was a secondary break; in other words, it occurred after the rod seized to the crankshaft. The bearing surface indicates that the initial seizure was from insufficient lubrication.

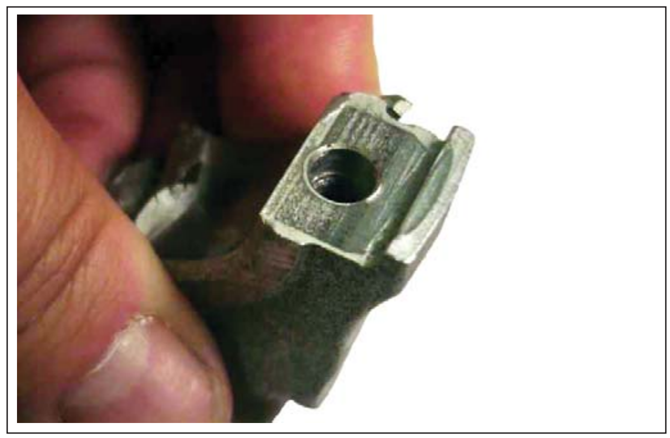


Figure 87.

Figure 87 – Sometimes you may only have a small amount of evidence to look at to make a determination as to what happened. This lower rod cap shows some peening and shifting. This could have been caused by a loose rod bolt. Again you have to look for other signs, and/or ask questions of the owner and/or of the engine itself. In this case the unit had plenty of lubrication. The failure occurred shortly after an overhaul by a service technician who forgot to torque the rod bolt to proper specifications.

Figure 88.

Figure 88 – This is a head assembly from a Command Engine. Notice the heavy carbon deposit on the face of the head and valves. The combustion deposits appear to be wet or shiny. This is an indication that excessive oil was entering the combustion chamber.

Figure 89.

Figure 89 – This is a close up of a Command head gasket. Notice the RTV sealant around the return passages. Someone wanted to get a positive seal between the head and block and applied RTV. This is not necessary if the surface areas are clean and dry as well as making sure there is no warpage. It is also good practice to check the recommended replacement data when it comes to the retaining fasteners.

Figure 90.

Figure 90 – Here is a close-up of the piston and wrist pin area. Notice the blackened and burnt deposits in the wrist pin area as well as the rest of the piston skirt. This can be caused by multiple factors. Some which would be poor oil quality, infrequent oil changes and/or overheating.

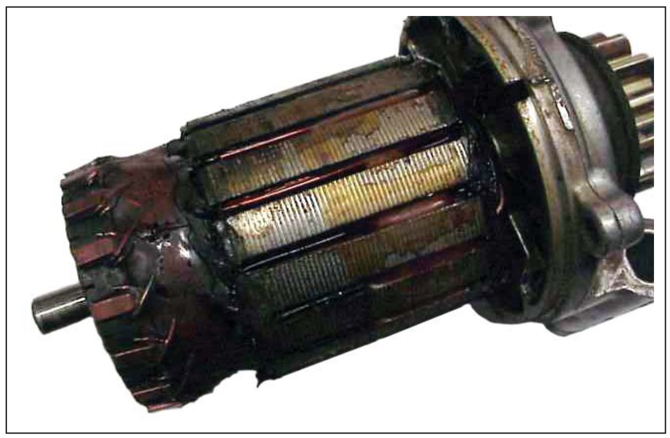


Figure 91.

Figure 91 – This is a typical starter motor winding burned up due to overheating. Again, your job as a technician is to determine what can cause this to occur. Was it due to overcranking and not allowing it to cool down? Was it do to parasitic loads? Improper voltage, etc.

Figure 92.

Figure 93.

Figure 92 - On the crankshafts look for signs of dirt wear, lack of lubrication and or side loading. Note condition of all bearing surfaces. In this case, notice the PTO bearing shows signs of severe scoring. This could indicate a lubrication or excessive side load problem. It could also be caused by a faulty electric clutch.

You Call the Failure

The following four (4) pictures are parts that have failed.
Take a look at the pictures and try to decide what could have caused each failure.

Figure 94.

Figure 95.

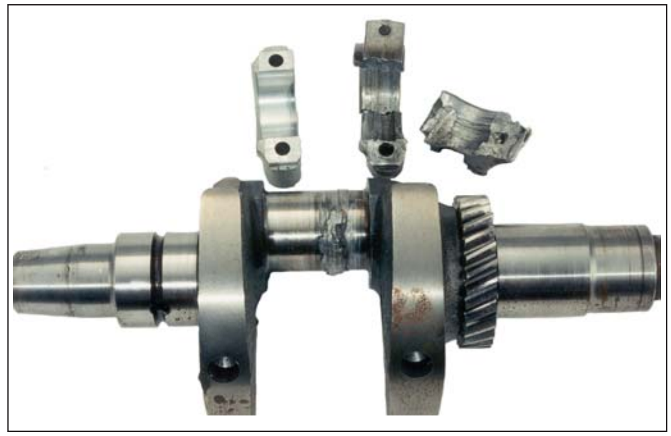


Figure 96.

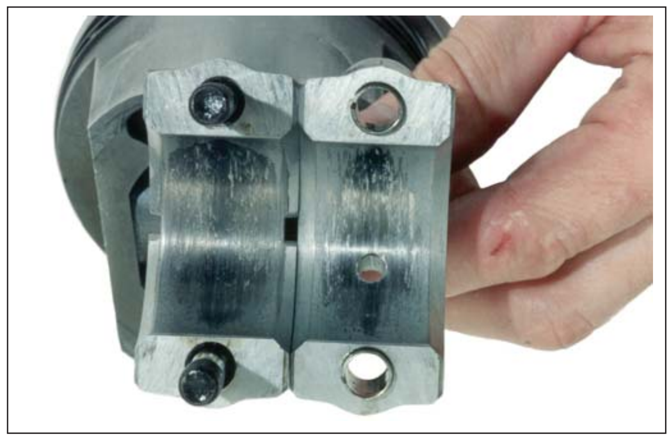


Figure 97.

D. Summary

Failure analysis is an important part of the small engine repair business. Some failures can be interesting and challenging. Others can be quite puzzling, almost exasperating. But if you follow the steps outlined in this booklet, you'll be more successful in reaching a logical, correct decision and completing the proper repair.

Figure 98.

- Make a thorough preliminary examination to help determine the conditions under which the engine was operated and pick up any external signs of factors that may have contributed to the failure. In some cases, there will be very obvious indicators, but not always. This engine ran for over two hours, no load, with no oil in the crankcase, but there are no external indicators of that.

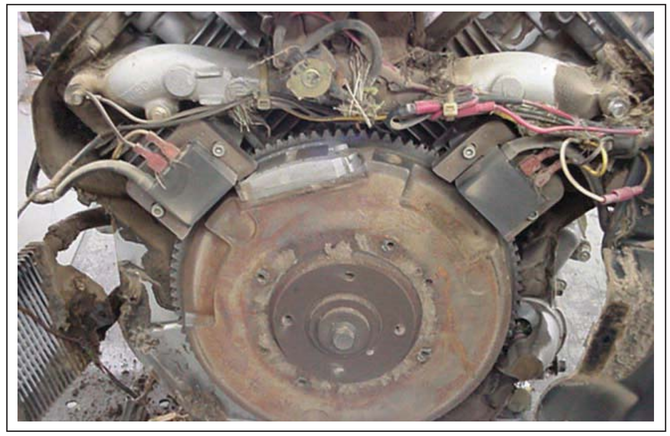


Figure 99.

- Carefully disassemble the engine and examine all of the components. Even though some parts weren't involved in the actual failure, they may still provide some indicators to assist you in reaching a correct decision. If you are fortunate the location of the failure is or will be obvious.

- Weigh all of the evidence against your experience as a professional small engine repairman. Your final decision should incorporate all of the evidence and provide a logical, sensible explanation for the failure which occurred. Running an engine out of gas doesn't cause a connecting rod failure, but running it out of oil probably will.

Once you have made an assumption, back up your decision with facts and measurements.

Figure 100. Carbon – Due to what?

Figure 102. Take Precise Measurements.

Figure 101. Rolled Material – Caused by what?

KOHLER engines

Engine Inspection Data Record

To facilitate accurate evaluation:

- enter as much information as possible
- provide as many dimensions as possible.
- mark location of break or crack on drawing
- record conditions found with check mark (X) whenever possible

SECTION 1 OWNER AND EQUIPMENT INFORMATION

Owner's Name	Street Address		
City	State	Zip Code	Phone No. ( ) –
Model No.	Spec. No.		Serial No.
Type of Equipment		Manufacturer of Equipment	
Date Purchased	Date Failed	Hours Used	Times Used
Previous Repairs ☐ YES ☐ NO	Warranty Claim No.		

USAGE/MAINTENANCE INFORMATION

Oil type: ☐ 30W ☐ 10W-30 10W-40 ☐ 5W-20 5W-30 ☐ Other ______	Hours since last oil change?
How often is the oil level checked? ☐ Everytime ☐ Never ☐ Other ______	Must oil be added between changes? ☐ Yes ☐ No ☐ How much? ______
Was an oil additive used? ☐ Yes ☐ No What brand? ______	How often is the air cleaner checked? Precleaner ______ Element ______
Was it ever replaced or cleaned? Precleaner: ☐ Yes ☐ No Element: ☐ Yes ☐ No	How recently? Precleaner ______ Element ______
Were any adjustments made to the carburetor or governor? ☐ Yes ☐ No If yes, specify ______	By whom? ☐ Customer ☐ Dealer

PRELIMINARY EXAMINATION

Air Cleaner Assembly

Type: ☐ Dry ☐ Precleaner ☐ Remote ☐ Oil Bath ☐ Tri-Phase

1. Wing Nut: ☐ Factory Original ☐ Non-standard replacement — Wing nut seal: ☐ Intact ☐ Separated ☐ Missing
2. Outer Cover: ☐ Good condition ☐ Center hole oblong ☐ Other damage (specify) ______
3. Precleaner: ☐ Clean ☐ Dirty ☐ Plugged ☐ Oiled ☐ Dry ☐ Torn ☐ Other damage ______
4. Inner Cover: ☐ Retaining seal/nut in place ☐ Center hole oblong ☐ Distorted ☐ Other damage ______
5. Element: ☐ Clean ☐ Dusty ☐ Dirty ☐ Plugged ☐ Missing ☐ Dry ☐ Non-factory replacement ☐ Other damage ______
6. Element seals: ☐ Pliable ☐ Hard ☐ Sealing ☐ Leaking ☐ Other damage ______
7. Air cleaner base: ☐ Tight ☐ Loose ☐ Screw(s) missing ☐ Distorted/Cracked ☐ Breather hose detached ☐ Other damage ______

Crankcase Oil

1. Amount on dipstick: ☐ Overfilled ☐ Full ☐ Above "add" ☐ Below "add" ☐ No reading
2. Condition of oil: ☐ New ☐ Used ☐ Dirty ☐ Black ☐ Thick/Sticky ☐ Burnt smelling ☐ Fuel diluted
3. Quantity of oil: Amount drained: ______ Amount req'd. ______

Observations: ☐ Metal chips present ☐ Sludge present ☐ Non-factory oil filter

TP-2435

(Continued on page 2)

Preliminary Examination (Cont.)

Cooling System

1. Flywheel Screen:
☐ Clean ☐ Plugged ☐ Partially blocked (%) ______

2. Cooling fins:
☐ Clean ☐ Plugged ☐ Partially blocked (%) ______

3. Engine exterior:
☐ Clean ☐ Dirty ☐ Oily ☐ Evidence of prior disassembly or repair ☐ Visible oil leaks (where) ______

Carburetor and Fuel Supply

1. Condition of carburetor:
☐ Okay ☐ Broken ☐ Loose ☐ Shafts worn ☐ Dirt in throat

2. Settings:
☐ Main fuel adj. ______ ☐ Idle fuel adj. ______

3. Condition of fuel:
☐ Clean ☐ Fresh ☐ Stale ☐ Contaminated (water, debris, etc.)

Governor

1. Components:
☐ Intact ☐ Missing ☐ Modified ☐ Bent/Broken

2. Function:
☐ Operative ☐ Inoperative ☐ Modified ☐ Misadjusted

Dirt Ingestion

1. Is there evidence of possible dirty entry via:
☐ Air cleaner ☐ Carburetor ☐ Breather ☐ Gasket/Seal ☐ Oil fill opening ☐ Other ______

Spark Plug

Spark Plug	Cylinder 1	Cylinder 2	Combustion Deposits	Cylinder 1	Cylinder 2
Gap	in.	in.	Light	☐	☐
Make			Heavy	☐	☐
Number			Color	☐	☐

SECTION 2 EVALUATION PERFORMED BY

Evaluator	Date
Company Name	Type of Acct. ☐ Central Distributor ☐ Service Distributor ☐ Service Dealer
Address	

City	State	Zip Code	Phone No.

TEAR DOWN ANALYSIS

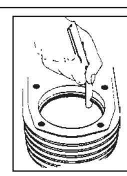
VALVES	CYLINDER 1		CYLINDER 2	
Stuck	☐	☐	☐	☐
Face Burned	☐	☐	☐	☐
Bent	☐	☐	☐	☐
Guide Worn	☐	☐	☐	☐
Not Damaged	☐	☐	☐	☐

CLEARANCE: (COLD)	CYLINDER 1	CYLINDER 2
Intake	in.	in.
Exhaust	in.	in.

CONNECTING ROD	CYLINDER 1	CYLINDER 2
Discolored	☐	☐
Broken	☐	☐
Bearing Scored	☐	☐
Cap Screws Loose	☐	☐
Dipper Bent	☐	☐
Dipper Broken	☐	☐
Rod Seized to Crankpin	☐	☐
Rod OK - Not Damaged	☐	☐

PISTON RINGS	CYLINDER 1	CYLINDER 2
Production Rings	☐	☐
Service Rings	☐	☐
Rings Free in Grooves	☐	☐
Rings Stuck in Grooves	☐	☐

End Gap:



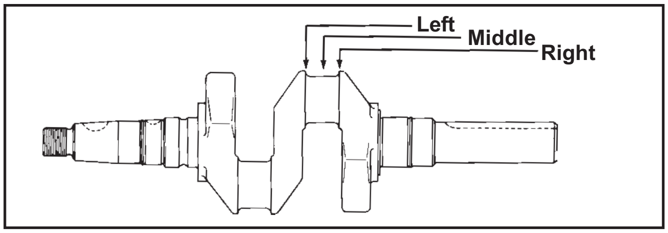
End Gap	CYLINDER 1	CYLINDER 2
Top	______ in.	______ in.
Center	______ in.	______ in.
Oil	______ in.	______ in.

Note: For Crankshaft, Pistons & Cylinder Bore Measurements – See Page 3.

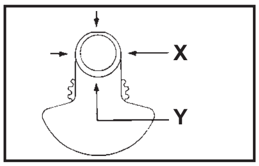
(Continued on page 3)

Tear Down Analysis *(continued)*

CRANKSHAFT ROD JOURNAL



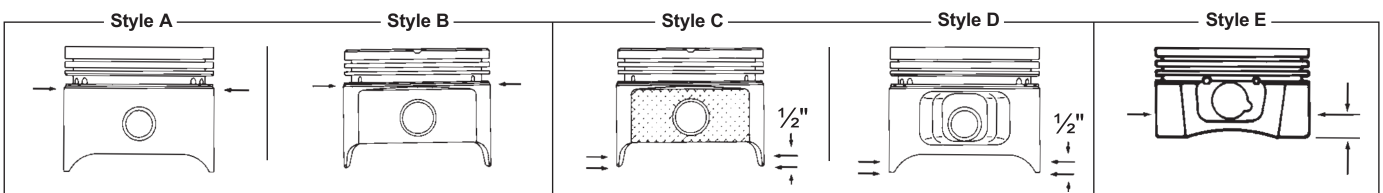
	CYLINDER 1	CYLINDER 1
Scored	☐	☐
Worn	☐	☐
Unmeasureable	☐	☐
Broken	☐	☐
Not Damaged	☐	☐
Others		
Maximum Wear Spec.		



	CYLINDER 1		CYLINDER 2		MAX. OUT OF ROUND
	X	Y	X	Y	
Left					
Middle					
Right					
Max. Taper					

PISTON

Select the following piston type and measure diameter using appropriate method.



Measure just below oil ring groove and at right angle to piston pin.

Measure 1/2 inch above the bottom of the skirt and at right angle to piston pin.

Measure 6 mm (0.24 in.) above the bottom of piston skirt at right angles to piston pin.

	CYLINDER 1	CYLINDER 2
Scored	☐	☐
Worn	☐	☐
Cracked	☐	☐
Broken	☐	☐
Ring Grooves Worn	☐	☐
Galled	☐	☐
Discolored	☐	☐

	CYLINDER 1	CYLINDER 2
Scratched	☐	☐
Not Damaged	☐	☐
Others ______		

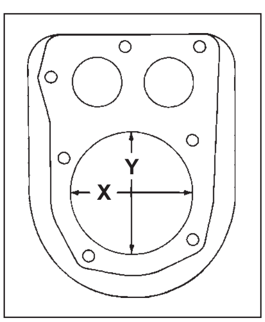
	CYLINDER 1	CYLINDER 2
Piston Diameter	______	______

CYLINDER BORE

	CYLINDER 1	CYLINDER 2
Bore Scored	☐	☐
Worn	☐	☐
Not Damaged	☐	☐

Others ______

MAXIMUM WEAR SPEC. ______



	CYLINDER 1		CYLINDER 2		MAX. OUT OF ROUND
	X	Y			
Top					
Center					
Bottom					
Max. Taper					

KOHLER® engines

BORN TO RUN™

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

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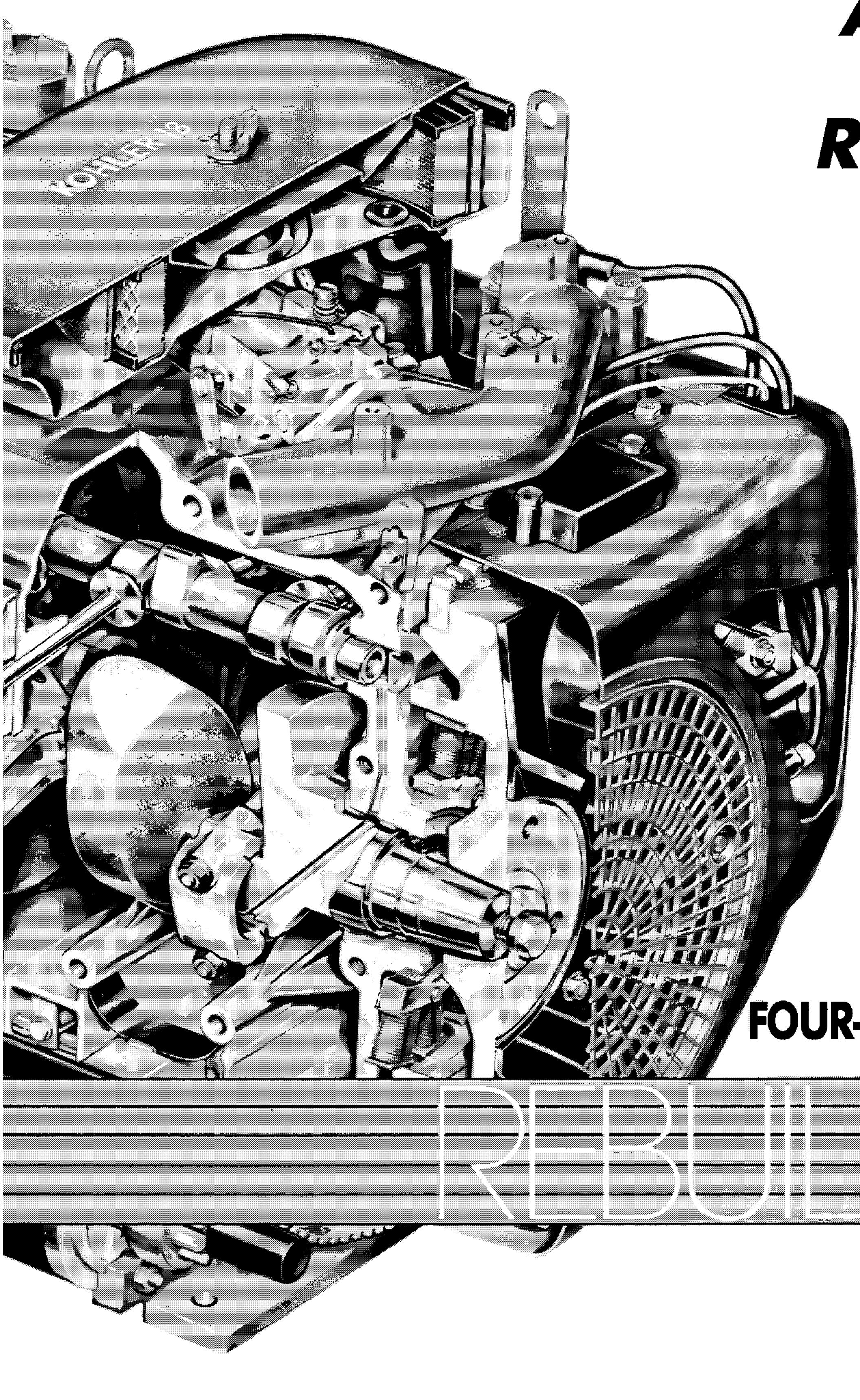
KOHLER engines

A GUIDE TO ENGINE REBUILDING



SINGLE-CYLINDER
TWIN-CYLINDER
FOUR-CYCLE/AIR-COOLED

REBUILDING

Long-life strength and on-the-job durability are designed and built into Kohler engines. Parts subject to most wear and tear – like cylinders, crankshafts, and camshafts – are made from precision formulated cast iron...and because the iron cylinders can be rebored, engines last even longer.

This guide provides information and instructions for rebuilding Kohler single cylinder and twin cylinder engines.

Before attempting to rebuild a Kohler engine, it is important to fully diagnose the engine problem and its cause. Insure that all simple and easy remedies are tried before adjusting or repairing the engine. A simple engine problem may be made a complex problem, if this procedure is not followed. As always, follow the specification recommended by Kohler when reassembling and adjusting.

CONTENTS

General Information

Inspection, Overhaul

SAFETY

Observe all rules of safety when servicing engines. Follow the manufacturer's instructions carefully when using cleaning solvents and other flammable liquids—and make sure they are properly identified and stored in covered containers safely away from the danger of combustion from open flames, sparks, etc.

PRELIMINARY CHECKS

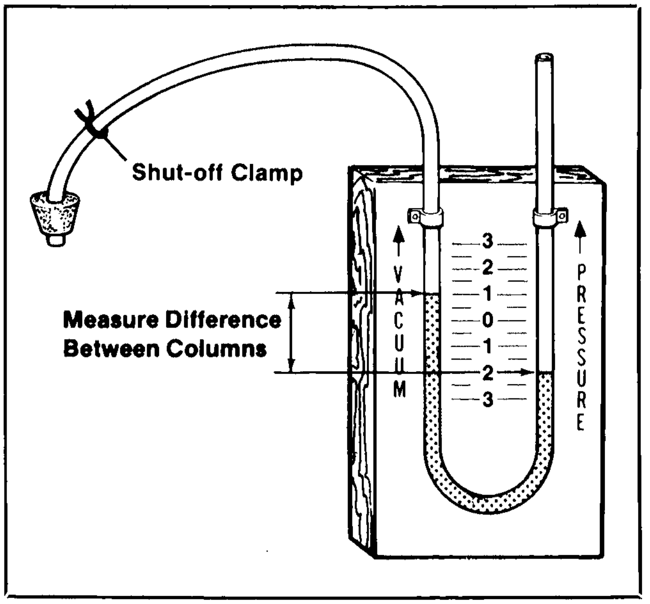
During disassembly, carefully inspect and note the physical appearance of each of the components. Often the appearance of parts will indicate engine operation under other than ideal conditions. Some of the things to look for are:

Excessive Sludge: This is a natural by-product of combustion and a small accumulation is normal. Excessive sludge formation could indicate several things: perhaps too infrequent oil changes; operation with improper ignition timing; or overrich carburetor adjustment, to name a few.

Scoring of the Cylinder Walls: Unburned fuel not only adds to sludge formation but can, in severe cases, cause scuffing and scoring of the cylinder walls. As raw fuel seeps down the cylinder walls, it washes the necessary lubricating oils off the piston and cylinder walls so that the piston rings make metal to metal contact with the walls. Scoring of the cylinder walls can also be caused by localized hot spots resulting from blocked cooling fins or from inadequate or contaminated lubrication.

Severe Piston Damage: Major damage to pistons and rings can take various forms. The top of the piston ring may be burned through or the top groove may be excessively worn and the ring broken or stuck in the groove. This can be attributed to abnormal combustion. If ignition timing is overadvanced, ignition will occur while the piston still has a long distance to travel on its compression stroke. As a result, the combined heat of compression, plus the heat of pre-ignited fuel, raises temperatures to values comparable to that of an acetylene torch. This, of course, acts mainly on the top land and top ring of the piston and results in early failure. A lean fuel mixture, excessive back pressure, or intake leaks, can also cause high temperatures.

Evidence of External Oil Leakage: If excessive oil leakage is evident, this may indicate improperly serviced breather systems. Normally, an engine operates internally at pressures less than atmospheric or, in other words, with a crankcase vacuum. If positive pressures build up within the crankcase from a clogged breather or from piston blowby, oil will be forced out of an engine at oil seals, gaskets, or any other available spot. Positive pressures can also be caused by worn seals, loose dipstick, or clogged crankcase breather holes.



CLEANING

All parts should be thoroughly cleaned—dirty parts cannot be accurately gauged or inspected properly for wear or damage. There are many commercially available cleaners that quickly remove grease, oil, and grime accumulation from engine parts. If such a cleaner is used, *follow the manufacturer's instructions carefully*, and make sure that all traces of the cleaner are removed before the engine is reassembled and placed in operation. Even small amounts of these cleaners quickly break down the lubricating properties of engine oils.

Soap and warm water works nicely to thoroughly remove the cleaner. Remember to dry and lubricate the engine parts immediately after cleaning.

Gasoline should never be used as a cleaning solution because of its many safety hazards. Gasoline fumes are explosive, and the fuel is easily ignited. The ignition spark may be sufficient to explode the entire area. *Play safe! Do not use gasoline for cleaning!*

Use ventilating fans, or provide ventilation by some other means, when cleaning. Some solutions give off toxic or noxious fumes; other fumes are highly combustible.

MEASURING TOOLS

There are a number of measuring tools which are required to correctly rebuild a Kohler engine. These include:

- Outside and inside micrometers
- Dial indicators
- Telescoping gauges
- Bore gauges
- Feeler gauges
- Torque wrenches
- Plastigage

Outside Micrometers: Outside micrometers are used to check the diameters of engine parts such as the pistons and crankshaft.

Inside Micrometers: Inside micrometers are used to measure the distance between two parallel surfaces. The inside micrometer will measure the dimensions of the cylinder bore, connecting rod pin diameters, sleeve bearings, etc.

Dial Indicators: A dial indicator is a gauge which uses a dial face and a needle to register measurements. There is a movable contact arm on the dial indicator. Dial indicators are calibrated in thousandths of an inch and typically, are used to measure end play and runout on crankshafts, gears, etc.

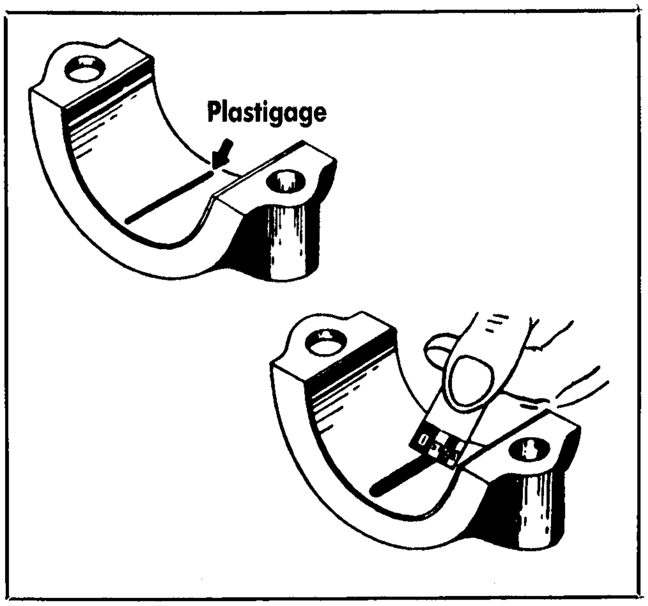
Telescoping Gauges: Telescoping gauges can take the place of an inside micrometer to measure the inside of bores, connecting rod pin diameters, etc.

Bore Gauges: Bore gauges are used to measure the diameter of cylinder bores. They may be used in place of an inside micrometer or telescoping gauge.

Feeler Gauges: Feeler gauges are used for measuring crankshaft and camshaft end play, valve clearance, piston ring end gaps, etc.

Torque Wrenches: Torque wrenches are used to deliver and monitor the specific limit (torque) to which a fastener can be safely stretched. Four types of torque wrenches are used; direct reading, dial, clutch, and click.

Plastigage: Plastigage provides a fast and accurate way to check running clearances. Plastigage is a soft plastic that will flatten out to predetermined widths when subjected to pressure. These widths will equal a specific clearance. Plastigage is normally used to check the connecting rod to crankpin running clearance. The most common type is green Plastigage which is used to measure clearances from .001 to .003 inches.



GASKETS AND SEALANTS

Engine gaskets are made of different materials, depending upon the requirements of heat, the solution present, and the wear encountered. Some surfaces (particularly of two piece crankcases) are sealed with liquid gasket compound. Since most gaskets partially adhere to the surfaces after use, it is impractical to reuse a gasket. The cost of replacing a gasket that has been removed is only the cost of the gasket, but if a gasket is reused and leaks, further engine troubles may develop and the rebuild time is then added to the gasket cost. Always clean the surfaces carefully to remove all gasket particles. Be sure that all surfaces are clean and flat, not warped, gouged, or scratched. A gasket cannot compensate for wear, gouges, warping, misalignment, or dirt on the surface.

OIL SEALS

Seals are used to prevent the lubricant from leaking out of the crankcase, and to prevent dirt from entering. Whenever a rotating part moves through a stationary part, it is necessary to provide a seal. Seals are of several types. Basically, however, all seals consist of a sleeve, which is pressed or fit carefully into the stationary part, and a pliable wiper, which is sealed to the sleeve, and held against the rotating part by spring pressure. Some seals have one pliable part or lip at one face. Other seals have two lips, one facing in each direction. If a seal with a single lip is being installed, it is important that it is installed in the same direction as the original seal.

When a lubricated seal is inserted into a bore, the lip must not be deformed or torn, and the seal must be inserted squarely. The seal is usually damaged by removal, and should be replaced with each engine rebuild.

BEARING CARE

Ball bearings and sleeve bearings are used in Kohler engines. Generally, sleeve bearings are used on KT engines. Ball bearings must be replaced if they show signs of damage. If the bearings turn easily and quietly, and there is no evidence of scoring or grooving on the races, the bearings can be reused.

A sleeve bearing must be inspected for out-of-round. If the wear is uneven, the bore or outer diameter may be eliptical or the bore and outer axis may not be true. These defects are sufficient reason for replacing the bearing.

LUBRICATION

Keep parts oiled and insure that they are lightly coated with lubricant as they are cleaned and reassembled. Not only does this practice make reassembly easier, but it insures lubrication of the parts during initial operation of the engine after reassembly. Use the same oil to lubricate the parts that are used in the engine crankcase.

TORQUING AND TIGHTENING SEQUENCE

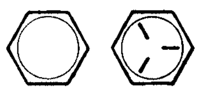
There are industry standards for the torque to which bolts should be tightened, depending on their size. However, most parts are secured by tightening the bolts or screws as tightly as reasonable. Some parts must be held with a specific torque. These should be tightened with a torque wrench. When torques are not specified, the standard torque specified by size should be used. Whenever Kohler Co. has listed a torque value to which a bolt or other part is tightened, it is important that the torque be observed. Parts that are torqued include: flywheel retaining screw or nut, closure plate screw, cylinder head screws, cylinder barrel stud nuts, connecting rod screws or nuts, crankcase stud nuts, crankcase cap screws, and spark plug.

In addition to the torque values, another important consideration is the sequence to be observed when tightening bolts or screws. Always tighten the bolts or screws in stages, tightening each approximately the same amount each time.

Tightening Torque Into Cast Iron or Steel

Size	Grade 2	Grade 5	Grade 8
8-32	20 in. lb.	25 in. lb.	
10-24	32 in. lb.	40 in. lb.	
10-32	32 in. lb.	32 in. lb.	
1/4-20	70 in. lb.	115 in. lb.	165 in. lb.
1/4-28	85 in. lb.	140 in. lb.	200 in. lb.
5/16-18	150 in. lb.	250 in. lb.	350 in. lb.
5/16-24	165 in. lb.	270 in. lb.	30 ft. lb.
3/8-16	260 in. lb.	35 ft. lb.	50 ft. lb.
3/8-24	300 in. lb.	40 ft. lb.	60 ft. lb.
7/16-14	35 ft. lb.	55 ft. lb.	80 ft. lb.
7/16-20	45 ft. lb.	75 ft. lb.	105 ft. lb.
1/2-13	50 ft. lb.	80 ft. lb.	115 ft. lb.
1/2-20	70 ft. lb.	105 ft. lb.	165 ft. lb.
9/16-12	75 ft. lb.	125 ft. lb.	175 ft. lb.
9/16-18	100 ft. lb.	165 ft. lb.	230 ft. lb.
5/8-11	110 ft. lb.	180 ft. lb.	260 ft. lb.
5/8-18	140 ft. lb.	230 ft. lb.	330 ft. lb.
3/4-10	150 ft. lb.	245 ft. lb.	350 ft. lb.
3/4-16	200 ft. lb.	325 ft. lb.	470 ft. lb.

Tightening Torque Into Aluminum



Size	Grade 2	Grade 5
8-32	20 in. lb	20 in. lb.
10-24	32 in. lb	32 in. lb.
1/4-20	70 in. lb	70 in. lb.
5/16-18	150 in. lb.	150 in. lb.

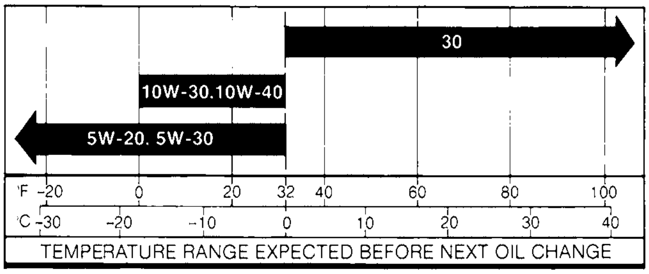
ENGINE BREAK-IN

Use straight SAE 30, SF-quality oil for the first 5 hours of operation. Change the oil after this initial run-in period. Refill with SF-quality oil as specified under "Oil Type."

Oil Type

Use high quality detergent oil of API (American Petroleum Institute) service class SF. Select viscosity based on the air temperature at the time of operation as shown below:

RECOMMENDED SAE VISCOSITY GRADES



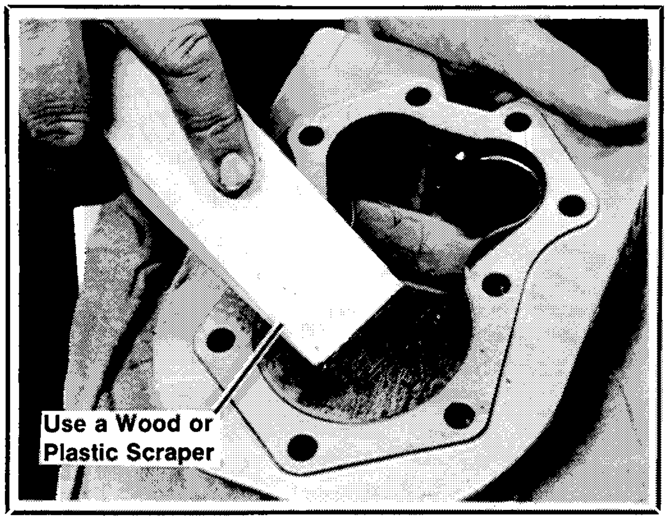
CYLINDER HEADS

Inspection

Blocked cooling fins often cause localized "hot spots" which can result in "blown" cylinder head gaskets. If the gasket fails in area surrounding one of the retaining capscrews, high temperature gases can burn away portions of the aluminum alloy head. A cylinder head in this condition must be replaced.

Service

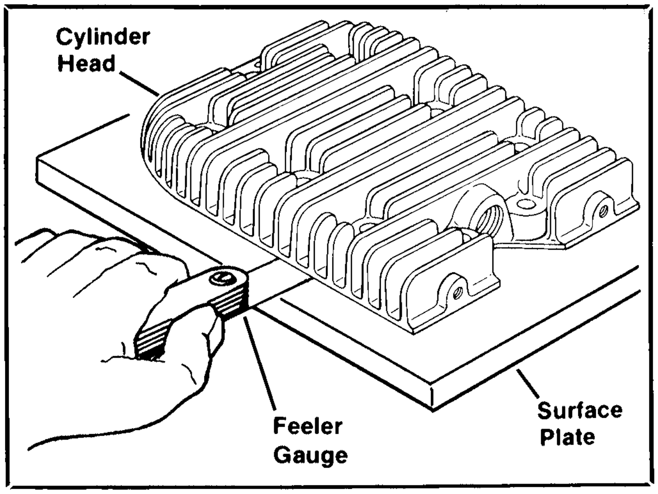
If the cylinder head appears to be in good condition, use a block of wood to scrape away carbon deposits. Be careful not to nick or scratch the aluminum, especially in gasket seating areas.



Cleaning Cylinder Heads

Cylinder head should also be checked for flatness. Use a feeler gauge and a surface plate or piece of plate glass to make this check. Clearance between the head and plate should not exceed .003" at any point. If it does, replace the cylinder head.

In cases where the head is warped or burned away, it will also be necessary to replace the head screws. The high temperatures that warped or burned the head could have caused them to stretch and lose their ability to retain proper torque.



Checking Cylinder Head Flatness

CYLINDER BLOCK/BARRELS

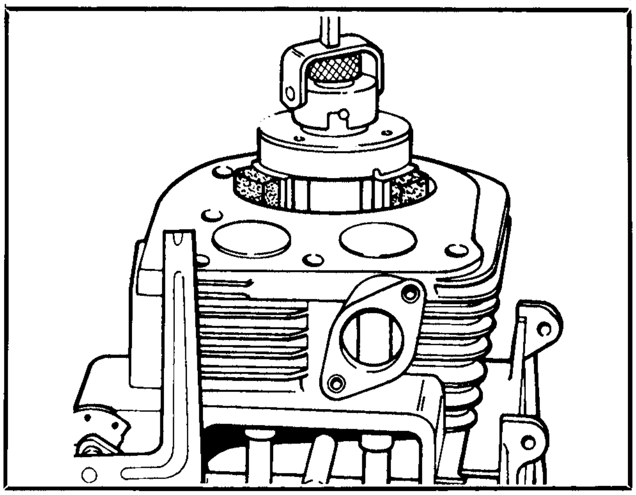
Inspection

Check all gasket surfaces to make sure they are free of gasket fragments. Gasket surfaces must also be free of deep scratches or nicks.

If the cylinder bore is badly scored, excessively worn, tapered, or out-of-round, resizing is necessary. Use an inside micrometer, telescoping gauge, or bore gauge to determine the amount of wear, refer to "Specifications and Tolerances", in the appropriate service manual, then select the nearest suitable oversize of either .010", .020", or .030". Resizing to one of these oversizes will allow usage of the available oversize piston and ring assemblies. Initially resize using a boring bar, then use the following procedures for honing the cylinder.

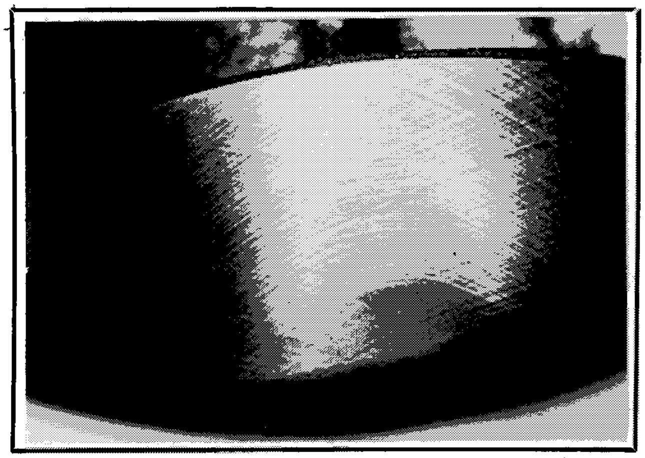
Honing

While most commercially available cylinder hones can be used with either portable drills or drill presses, the use of a low speed drill press is preferred as it facilitates more accurate alignment of the bore in relation to the crankshaft crossbore. Honing is best accomplished at a drill speed of about 250 RPM and 60 strokes per minute. After installing coarse stones in hone, proceed as follows:



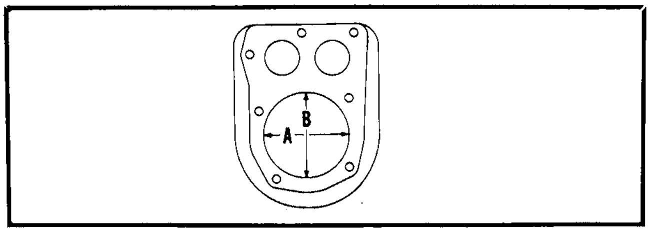
1. Lower hone into bore and after centering, adjust so that stones are in contact with walls. Use of a commercial cutting/cooling agent is recommended.
2. With the lower edge of each stone positioned even with the lowest edge of the bore, start drill and honing process. Move hone up and down while resizing to prevent formation of cutting ridges. Check size frequently.

   NOTE: Measure the piston diameter and resize the bore to the piston to obtain the specified running clearances. See "Measuring Piston to Bore Clearance". Keep in mind that the temperatures caused by honing may yield inaccurate measurements. Insure that the block is cool while measuring.
3. When bore is within .0025" of desired size, remove coarse stones and use finish stones (220-280) and polish to final size. A crosshatch pattern should result when honing is done correctly. The crosshatch should intersect at approximately 23-33° off the horizontal. Too flat an angle could cause the rings to skip and wear excessively, too high an angle will result in high oil consumption.



Cylinder Bore Cross-Hatch After Honing

4. After resizing, check the bore for roundness, taper, and size. Measurements can be made with an inside micrometer, telescoping gauge, or bore gauge. The measurements should be taken at three places in the cylinder; at the top, middle, and bottom. Two measurements should be taken, perpendicular to each other, at each of the three locations.



5. Carefully clean the cylinder wall with soap and hot water, then after drying thoroughly, apply a light coat of SAE 10 oil to prevent rust. Insure that the oil drain hole in the valve chamber is clean.

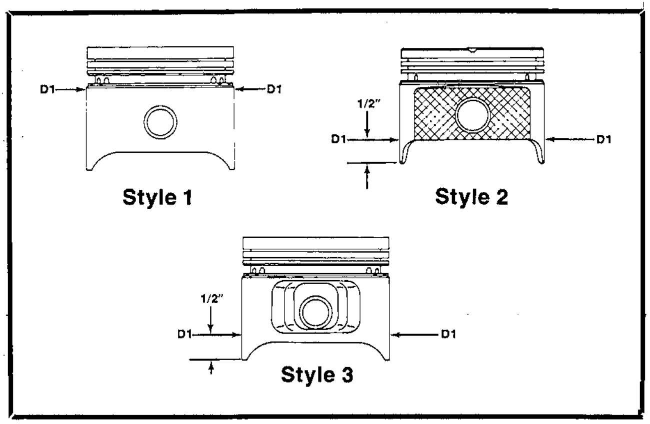
Measuring Piston to Bore Clearance

Before installing the piston into the cylinder bore, it is necessary that the clearance be accurately checked. This step is often overlooked, and if the clearances are not within specifications, generally engine failure will result.

NOTE: Do not use a feeler gauge to measure piston to bore clearance—it will yield inaccurate measurements—Use a Micrometer.

The following procedures should be used to accurately measure the piston to bore clearance.

1. Use a micrometer and measure the diameter of the piston (D1) at the appropriate position.



2. Use an inside micrometer, telescoping gauge, or bore gauge and measure the cylinder bore. Take the measurement approximately 2½" below the top of the bore and perpendicular to the piston pin.

The difference between the two measurements is the piston to bore clearance. If the clearance is within specifications, the piston may be used as is. If the clearance is not within specifications, resize and install the appropriate size piston and rings.

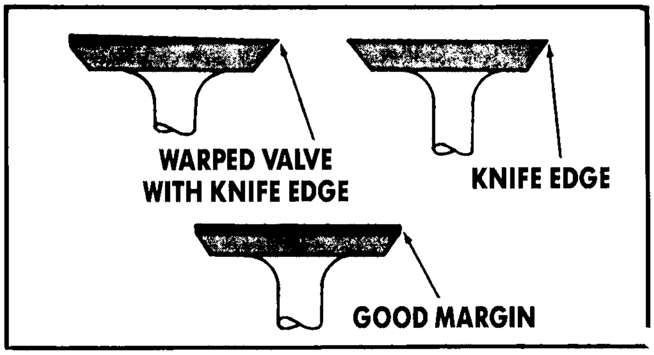
VALVES

Inspection and Service

Hard starting or loss of power accompanied by high fuel consumption may be symptoms of faulty valves. Carefully inspect all valve mechanism parts. Also, check the valve seat area or inserts for evidence of deep pitting, cracks, or distortion.

After removing the valve, clean the valve head, face and stem with a power wire brush, then carefully inspect for defects, such as warped valve head, excessive corrosion and worn or bent valve stems. Replace valves found to be in bad condition.

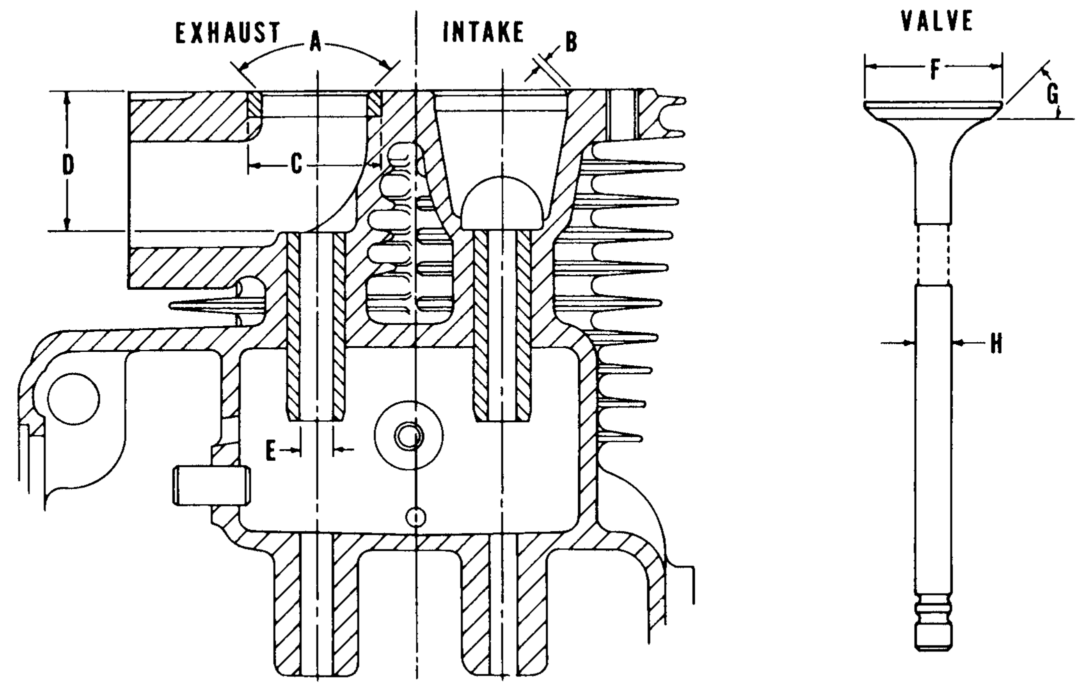
A valve can be reconditioned and reused, if the face and margin are in good shape. If a valve is worn to where the margin is less than 1/32″, do not reuse it.



Valve Guides

If a valve guide is worn beyond specifications, it will not guide the valve in a straight line. This may result in burnt valve faces or seats, loss of compression, and excessive oil consumption.

To check valve guide to valve stem clearance, thoroughly clean the valve guide and, using a split-ball gauge, measure the diameter. Then, using an outside micrometer, measure the diameter of the valve stem at several points on the stem where it moves in the valve guide. Use the largest stem diameter to calculate the clearance. If the clearance exceeds the specified limits,

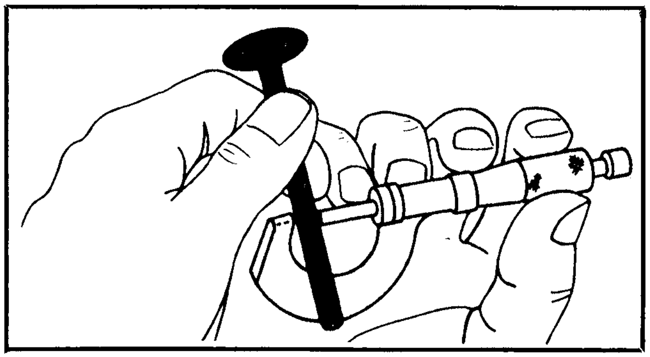


Valve	A Seat Angle	B Seat Width	C Insert O.D.	D Guide Depth	E Guide I.D.	F Valve Head Dia.	G Valve Face Angle	H Valve Stem Dia.
Intake	89°	.037″ .045″	–	1.586″	.312″ .313″	1.380″ 1.370″	45°	.3110″ .3103″
Exhaust	89″	.037″ .045″	1.5045″ 1.5035″	1.497″	312″ .313″	1.380″ 1.370″	45°	.3091″ .3085″

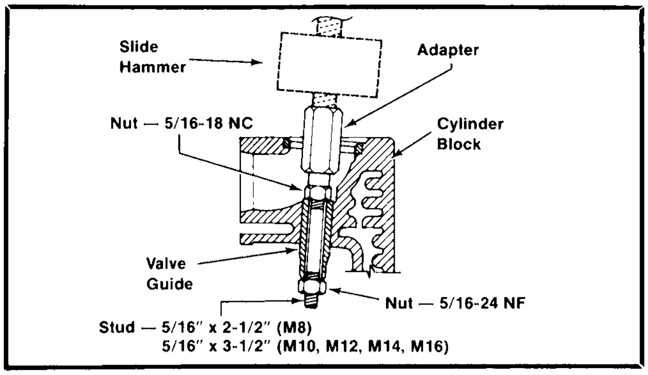
Valve Port Specifications

determine whether the valve stem or the guide is responsible for the excessive clearance.

If the valve stem diameter is within specifications, then replace the valve guide.

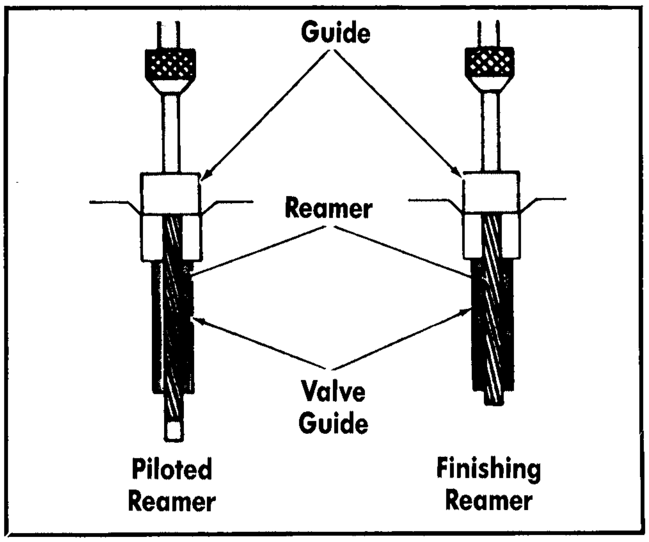


Remove guides with a special puller, a piloted pressing mandrel on a press, or a valve guide driver.



Pulling Valve Guide (Typical)

Clean the guide bores thoroughly before installing new guides and seats. Press the new guides in making sure they are properly seated. Valve guides are often slightly compressed during insertion. Use a piloted reamer and then a finishing reamer to resize the guide bore to the correct dimension.

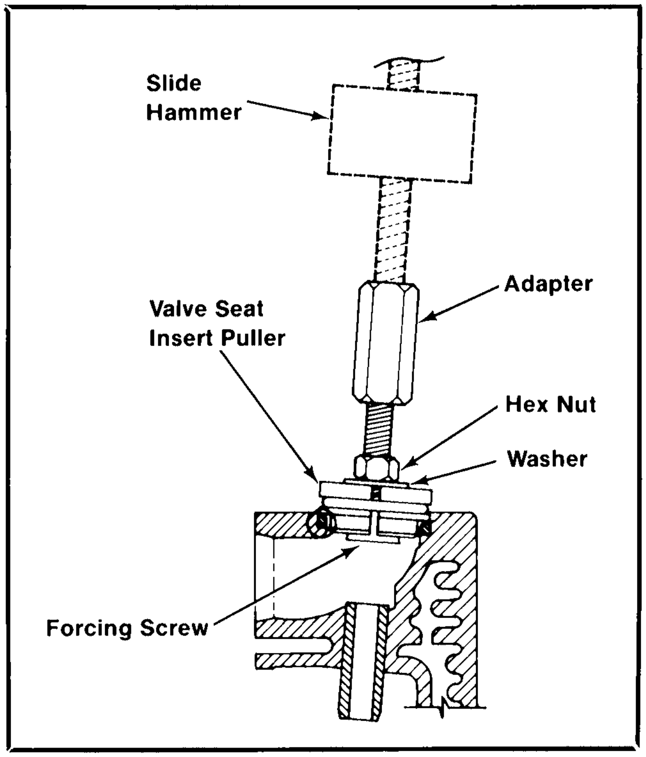


Valve Seat Inserts

Intake valve seats are usually machined into the cylinder block/ barrel, however, certain applications may specify hard alloy inserts. The exhaust valve seats are replaceable alloy inserts. If the seats become badly pitted, cracked, or distorted, the inserts must be replaced.

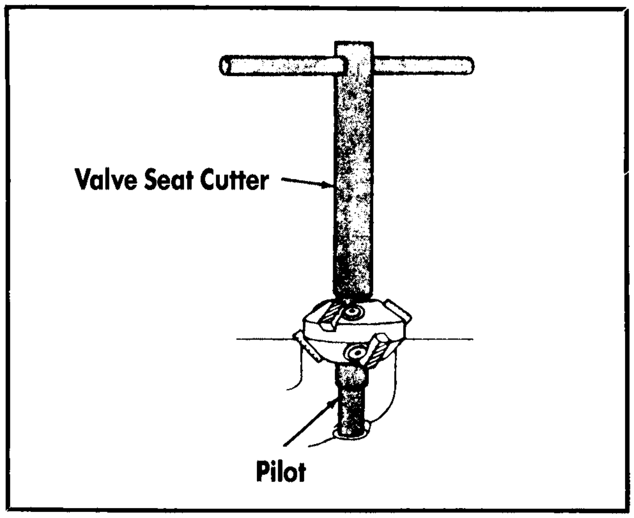
When replacing valve seat inserts, measure the width of the insert before removal to be sure you order the correct size insert.

The inserts are a tight press fit in the cylinder barrel. A commercial valve seat removal tool is recommended for this job. Since insert removal causes loss of metal in the insert bore area, use only Kohler service replacement inserts, which are slightly larger to provide proper retention in the cylinder block/barrel. Make sure new inserts are properly started and pressed into bore to prevent cocking of the insert.

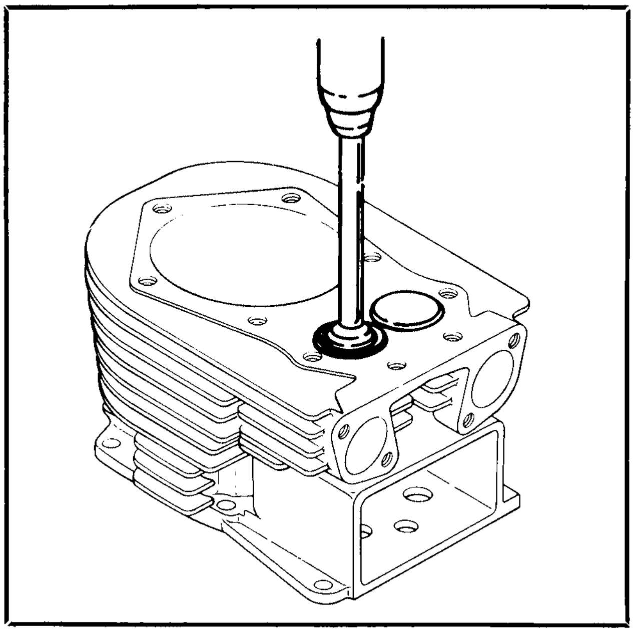


Pulling Valve Seat Insert (Typical)

Seating surfaces should be held between .037" and .045" width. Seats with more than .045° must be reconditioned with a 45° cutter and overcutting or undercutting with 30° and 60° cutters, to obtain the proper seat width, is recommended.



Reground or new valves must be lapped in, to provide proper fit. Use a hand valve grinder with suction cup for final lapping. Lightly coat valve face with "fine" grade of grinding compound, then rotate valve on seat with grinder. Continue grinding until smooth surface is obtained on seat and on valve face. Remove all traces of grinding compound.



Lapping Valves

Valve Stem Seals

Valve stem seals can be reused, but should be replaced when new valves are installed. Seals should also be replaced, if damaged, or deteriorated in any way.

Valve Springs

The valve springs are progressively wound; that is, coils are closer together on one end than the other. Valve springs are installed with the coils which are closer together, toward the cylinder head.

A valve spring will seldom wear out, but if it does, it will usually break. Broken springs must be replaced.

PISTONS AND RINGS

Inspection

Scuffing and scoring of pistons and cylinder walls occurs when internal temperatures approach the welding point of the piston. Temperatures high enough to do this are created by friction which is usually attributed to improper lubrication, improper clearance, and/or overheating of the engine.

Normally, very little wear takes place in the piston boss-piston pin area. If the original piston and connecting rod can be reused after new rings are installed, the original pins can also be reused, but new piston pin retainers are required. Piston pins are included as part of the piston assemblies—if the pin boss in piston or the pin are worn, or damaged, a new piston assembly is required.

Ring failure or wear is usually indicated by excessive oil consumption, blue exhaust smoke, or low crankcase vacuum. When rings fail, oil is allowed to enter the combustion chamber, where it is burned, along with the fuel. High oil consumption can also occur when gap is incorrect; rings cannot properly conform to the cylinder walls under this condition. Oil control is also lost when ring gaps are not staggered during installation.

When cylinder temperatures get too high, lacquer and varnish collect on pistons causing rings to stick, which results in rapid wear. A worn ring takes on a shiny or bright appearance. Scratches on rings and pistons are caused by abrasive material, such as carbon, dirt or pieces of hard metal.

Detonation damage occurs when a portion of the fuel charge ignites spontaneously from heat and pressure shortly AFTER ignition. This creates two flame fronts which meet and explode to create extreme hammering pressures on a specific area of the piston. Detonation generally occurs from using fuels with too low an octane rating.

Pre-ignition or ignition of the fuel charge BEFORE the timed spark can cause damage rather similar to detonation. Pre-ignition is often more severe than detonation damage—often a hole is quickly burned right through the piston dome by pre-ignition. Pre-ignition is caused by a hot spot in the combustion chamber from sources such as: glowing carbon deposits, blocked fins, improperly seated valves or wrong spark plugs.

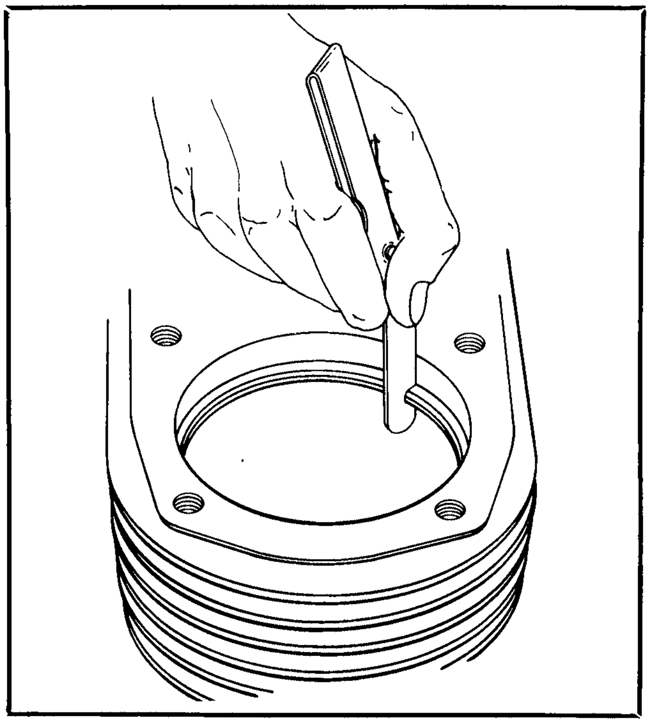
Service

Service ring replacement sets and piston assemblies are available in the standard size, and in .010", .020" and .030" oversize sets. The service oversize piston assemblies are used only when the cylinder has been rebored to the corresponding oversize. NOTE: If engine is .003 oversize and piston is to be replaced, use .003 piston and STD service rings.

Service type rings and piston assemblies are used when the cylinder is worn, but still within wear and out-of-round limits, refer to "Specifications and Tolerances", in the appropriate service manual. Service ring sets usually include expanders or other arrangements to provide uniform pressure on ring and better conformity to cylinder wall, regardless of wear. Cylinder bore must be deglazed before service ring sets are used.

Some important points to remember when servicing pistons and/or rings:

1. If the cylinder block does not need reboring, and if the old piston is within wear limits, and free of score or scuff marks, it may be reused.
2. Remove old rings and clean up grooves. Never reuse old rings.
3. Before installing new rings on piston, place top two rings each in turn in its running area in cylinder bore and check end gap. Refer to "Specifications and Tolerances" in the appropriate service manual for end gaps in used and new cylinder bores.

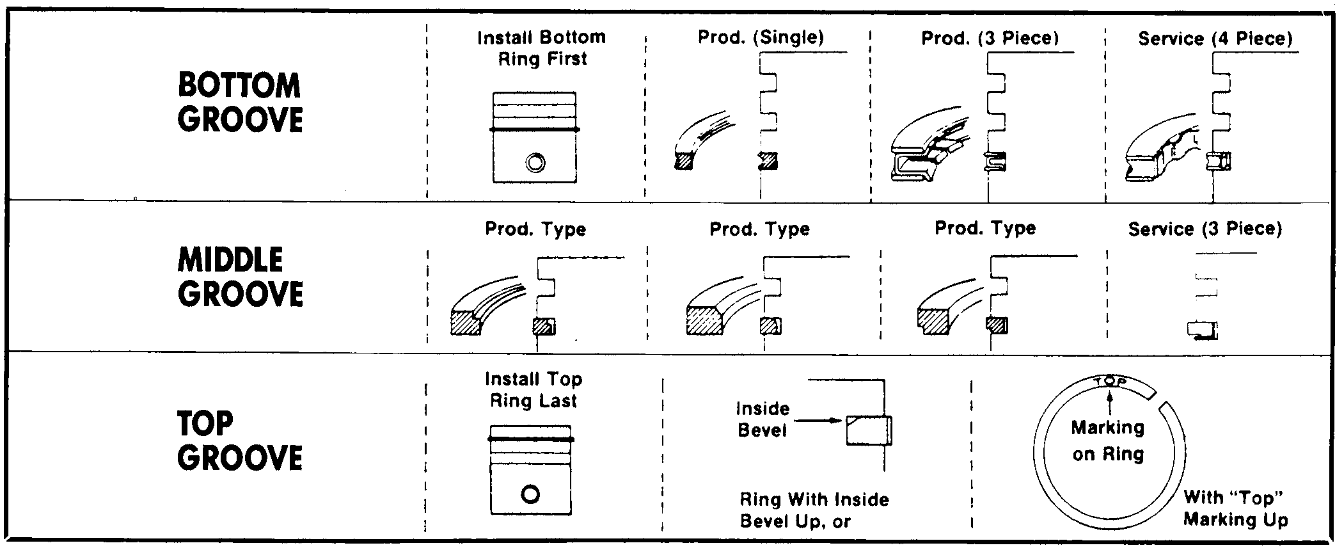


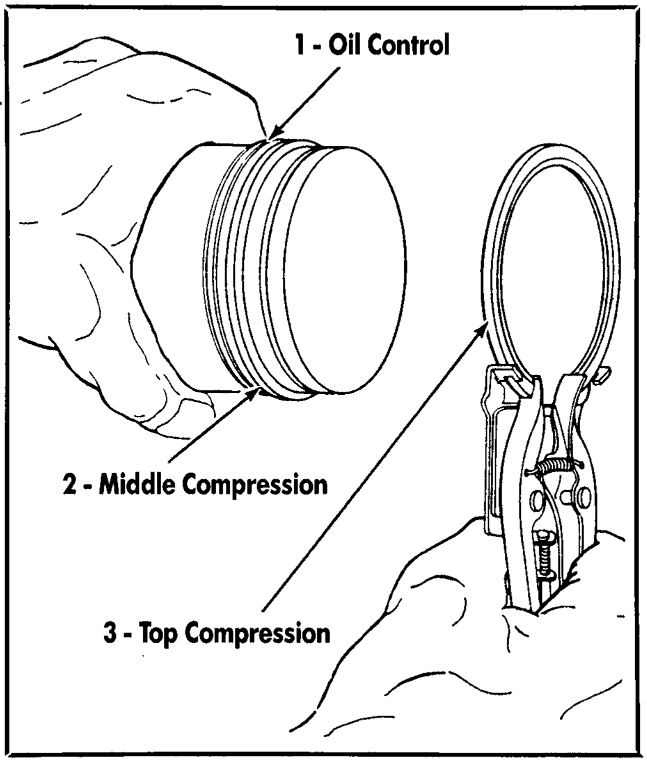
Measuring Piston Ring End Gap

NOTE: Deglaze and clean the cylinder bore prior to checking the end gaps of new rings.

In service ring sets, the oil ring may have end gaps as high as .060". Be sure to stagger ring and rails when installing.

4. Rings must be installed correctly. Ring installation instructions are usually included with new ring sets. Follow instructions carefully. Use ring expander to install rings and check side clearance of each ring after installation. For side clearances, refer to "Specifications and Tolerances" in the appropriate service manual.





Ring Installation Sequence

CONNECTING RODS

Inspection and Service

Check bearing area (big end) for excessive clearance (See Camshaft and Crankshaft, Inspection and Service), score marks and side clearances; refer to "Specifications and Tolerances" in the appropriate service manual. Replace rod if scored or excessively worn. Connecting rods with bearing diameter area .010" undersize are available for use with reground crankpin.

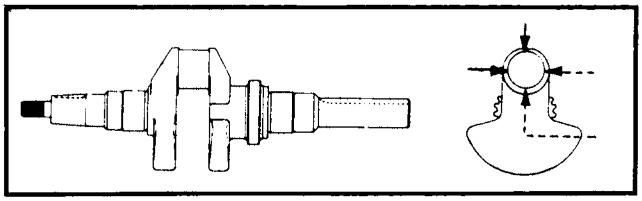
CAMSHAFT AND CRANKSHAFT

Inspection and Service

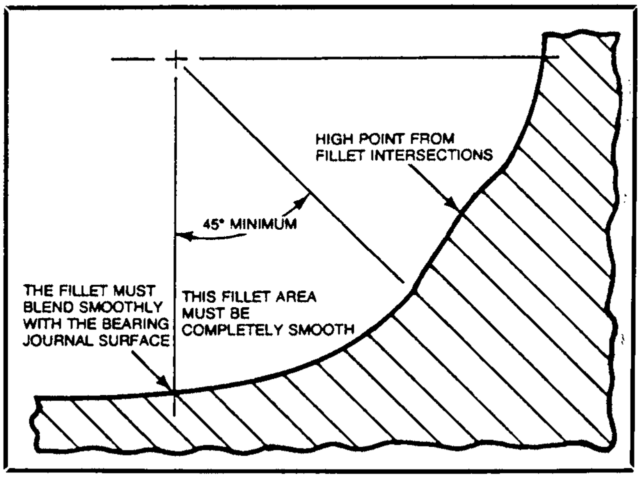
Inspect the gear teeth on both the crankshaft and camshaft. If the teeth are badly worn, chipped or some are missing, replacement of the damaged components will be necessary.

Also, inspect the crankshaft bearings for scoring, grooving, etc. Do not replace bearings unless they show signs of damage or are out of running clearance specifications. If crankshaft turns easily and noiselessly, and there is no evidence of scoring, grooving, etc., on the races or bearing surfaces, the bearings can be reused.

Check crankshaft keyways. If worn or chipped, replacement of the crankshaft will be necessary. Also inspect the crankpin for score marks or metallic pickup. Slight score marks can be cleaned with crocus cloth soaked in oil. If wear limits, as stated in "Specifications and Tolerances" are exceeded by more than .002", it will be necessary to either replace the crankshaft or regrind the crankpin to .010" undersize. If reground, a .010" undersize connecting rod (big end) must then be used to achieve proper running clearance. Measure the crankpin for size, taper and out-of-round.



NOTE: If the crankpin is reground, visually check to insure that the fillet blends smoothly with the crankpin surface.



To check clearance, install the connecting rod on the crankshaft and torque the rod bolts to 20% over the nominal value. Loosen bolts and remove the rod cap. Use Plastigage, replace the rod cap and torque the rod bolts to specifications.

Loosen the rod bolts, remove the rod cap and check the clearance on the Plastigage. Maximum allowable clearance is .0035", minimum is .001".

OIL PUMP

Inspection and Service

Check oil pump gear for any cracked, chipped, or badly worn teeth. Replace gear, if any of these problems exist.

Oil pump rotors and shaft are virtually troublefree and will require very little service.

GOVERNOR

Inspection

Inspect the governor gear teeth. Look for any evidence of worn, chipped, or cracked teeth. If one or more of these problems is noted, replace the governor gear and rotate to check for freedom of movement.

DYNAMIC BALANCE

Dynamic balance if found on some 10 and 12 Hp models and is standard on most 14 and 16 Hp engines. This system consists of two balance gears which run on needle bearings. The gear bearing units are assembled to two stub shaft which are press fitted into special bosses in the crankcase. Snap ring retainers hold the gears and spacer washers are used to control end play. The gears are driven off the crankgear in the direction opposite to rotation of the crankshaft.

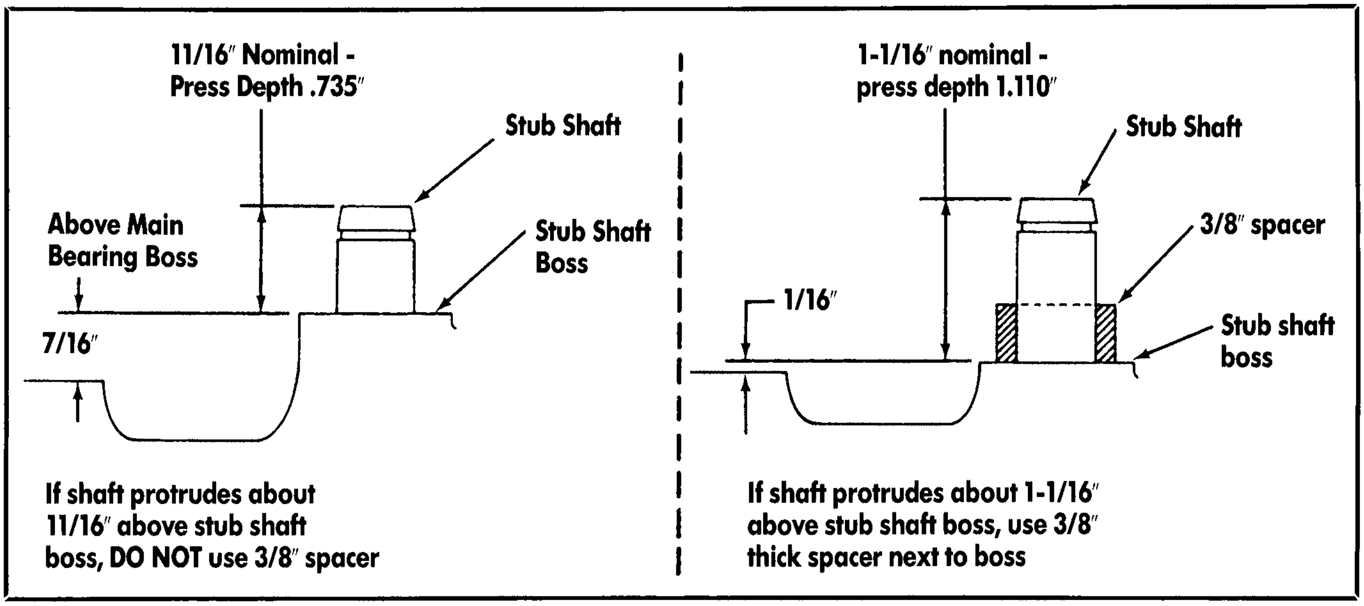
When working on Dynamic Balance models, care must be exercised to make sure that the proper end play is attained and that the gears are properly timed to the engine. Use the following procedure to install and time Dynamic Balance components.

Stub Shaft

If stub shaft is worn beyond specified diameters or damaged, press old shaft out and install a new shaft. Shaft must protrude a specific distance above the stub shaft boss. If the stub shaft boss is about 7/16″ above the main bearing boss, press the shaft in until it is .735″ above the stub shaft boss. On blocks where the stub shaft is only about 1/16″ above the main bearing boss, press shaft in until it is 1.110″ above the stub shaft boss—a 3/8″ spacer must be used with the shaft which protrudes 1.110″.

Balance Gear

Slip one .010″ spacer on the stub shaft, then install gear-bearing assembly on stub shaft (with timing marks out)—if assembly tool is not being used, do not install bottom gear until after the crankshaft is reinstalled. Proper gear end play (.002 - .010″) is attained with one .005″ spacer, one .010″ spacer, and one .020″ spacer which are installed on the snap ring retainer end of the shaft—install the thickest spacer (.020″) next to the retainer. After installing retainer, recheck end play and adjust (add or subtract .005″ spacers) if needed. NOTE: Install retainer with rounded edge facing spacers.



Stub Shaft Depth-Boss Height Variation

Timing

Many of the larger single cylinder models are equipped with dynamic balance. Refer to the appropriate service manual for service, reconditioning, and timing procedures.

FUEL PUMP

If it has been determined that the fuel pump is faulty, it should be replaced.

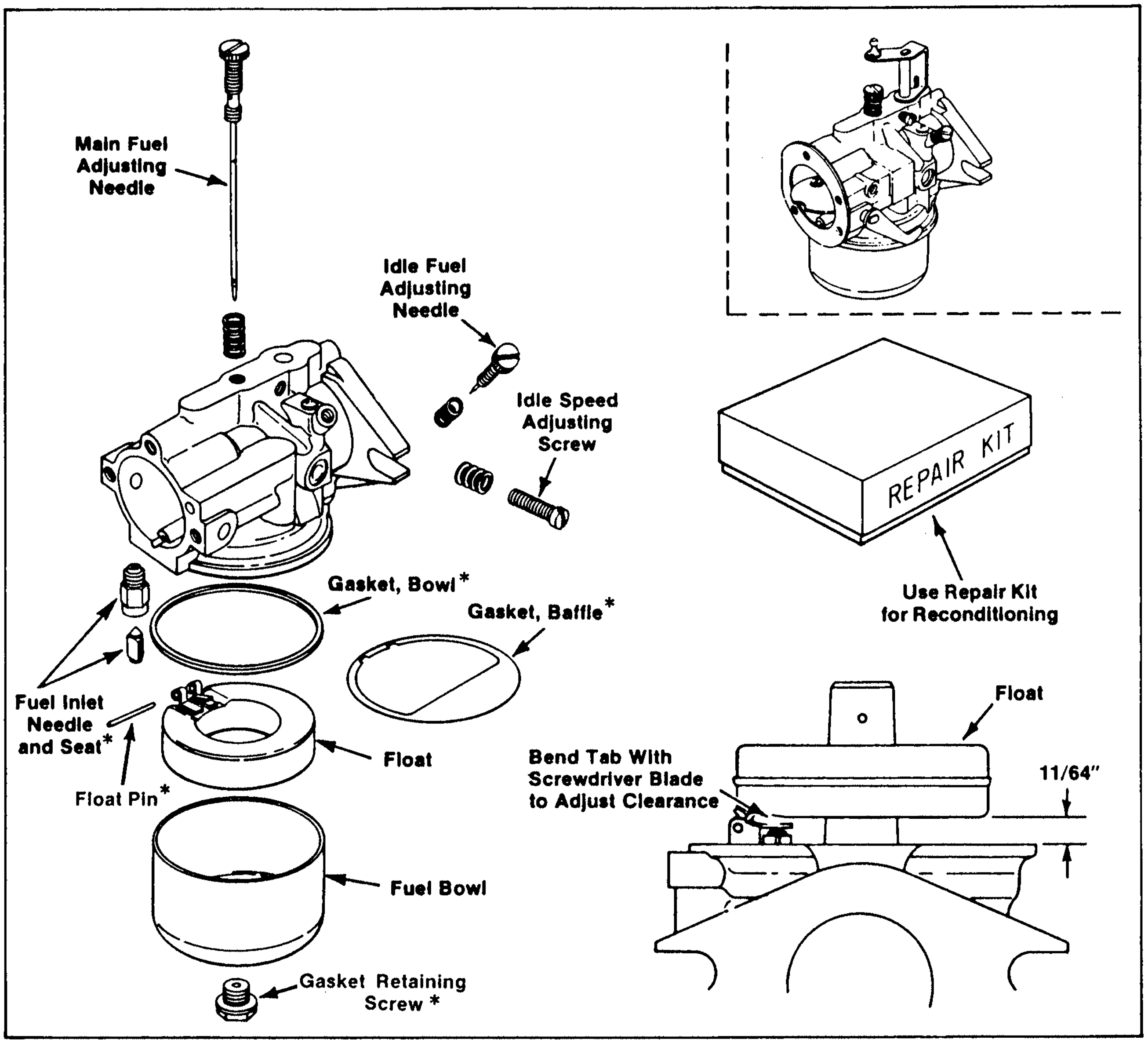
CARBURETOR

Difficulties with fuel systems usually originate from improper carburetor settings, or from dirt, gum or varnish in carburetor components. The necessity of cleaning will depend upon use and operating conditions. To clean thoroughly, it will be necessary to completely disassemble carburetor.

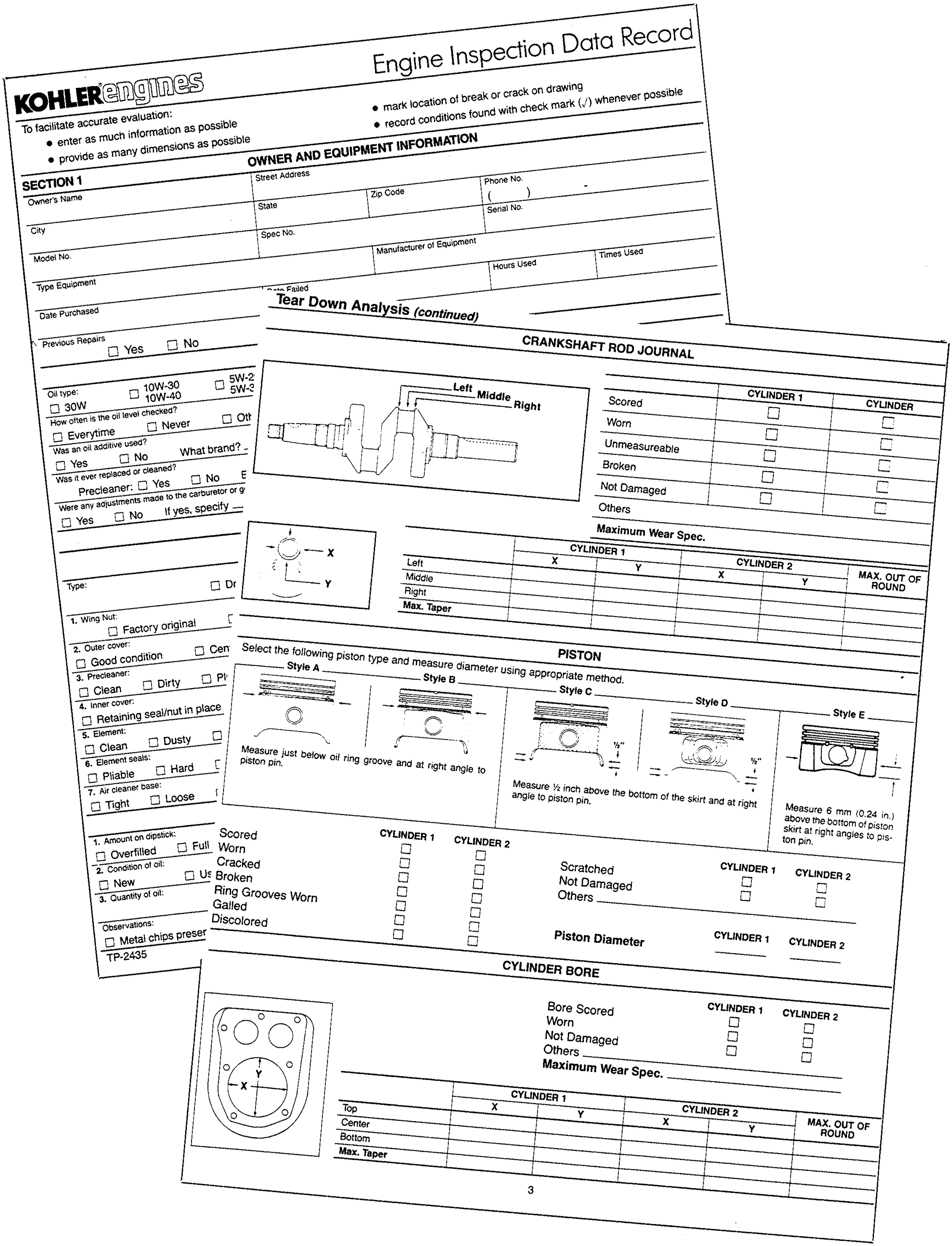
All parts should be cleaned in solvent. Carburetor should not be submersed in solvent, it may damage fiber and rubber seals. *Follow solvent manufacturer's warning and instructions on its proper and safe use.* Gum is easily removed with acetone solvent. Be sure all deposits are removed from bore, especially where throttle plate seats in casting. Blow out all passages with compressed air. Replace all worn and damaged parts. Always use new gaskets.

NOTE: Carburetors should be checked for loose throttle shafts. Loose shafts will allow dirt to enter the engine and may cause poor performance from leaks.

Carburetor repair kits are available from your Kohler parts supplier. Kits include a bowl retaining screw gasket, bowl ring gasket, float pin, bowl baffle, and fuel inlet needle and seat.



Included in Repair Kit



KOHLER engines

Engine Inspection Data Record

To facilitate accurate evaluation:
- enter as much information as possible
- provide as many dimensions as possible
- mark location of break or crack on drawing
- record conditions found with check mark (√) whenever possible

OWNER AND EQUIPMENT INFORMATION

SECTION 1

Owner's Name | Street Address | Phone No. ( ) -
City | State | Zip Code | Serial No.
Model No. | Spec No.
Type Equipment | Manufacturer of Equipment
Date Purchased | Hours Used | Times Used
Previous Repairs ☐ Yes ☐ No

Oil type: ☐ 30W ☐ 10W-30 10W-40 ☐ 5W-2 5W-3
How often is the oil level checked? ☐ Everytime ☐ Never ☐ Oth
Was an oil additive used? ☐ Yes ☐ No What brand?
Was it ever replaced or cleaned? Precleaner: ☐ Yes ☐ No E
Were any adjustments made to the carburetor or g ☐ Yes ☐ No If yes, specify

Type: ☐ Dr

1. Wing Nut: ☐ Factory original
2. Outer cover: ☐ Good condition ☐ Cen
3. Precleaner: ☐ Clean ☐ Dirty ☐ Pl
4. Inner cover: ☐ Retaining seal/nut in place
5. Element: ☐ Clean ☐ Dusty
6. Element seals: ☐ Pliable ☐ Hard
7. Air cleaner base: ☐ Tight ☐ Loose

1. Amount on dipstick: ☐ Overfilled ☐ Full
2. Condition of oil: ☐ New ☐ Us
3. Quantity of oil:

Observations: ☐ Metal chips preser

TP-2435

Tear Down Analysis *(continued)*

CRANKSHAFT ROD JOURNAL

Left Middle Right

	CYLINDER 1	CYLINDER
Scored	☐	☐
Worn	☐	☐
Unmeasureable	☐	☐
Broken	☐	☐
Not Damaged	☐	☐
Others	☐	☐

Maximum Wear Spec.

	CYLINDER 1 X	CYLINDER 1 Y	CYLINDER 2 X	CYLINDER 2 Y	MAX. OUT OF ROUND
Left					
Middle					
Right					
Max. Taper					

PISTON

Select the following piston type and measure diameter using appropriate method.

Style A, Style B: Measure just below oil ring groove and at right angle to piston pin.

Style C, Style D: Measure ½ inch above the bottom of the skirt and at right angle to piston pin.

Style E: Measure 6 mm (0.24 in.) above the bottom of piston skirt at right angles to piston pin.

	CYLINDER 1	CYLINDER 2
Scored	☐	☐
Worn	☐	☐
Cracked	☐	☐
Broken	☐	☐
Ring Grooves Worn	☐	☐
Galled	☐	☐
Discolored	☐	☐

	CYLINDER 1	CYLINDER 2
Scratched	☐	☐
Not Damaged	☐	☐
Others		
Piston Diameter		

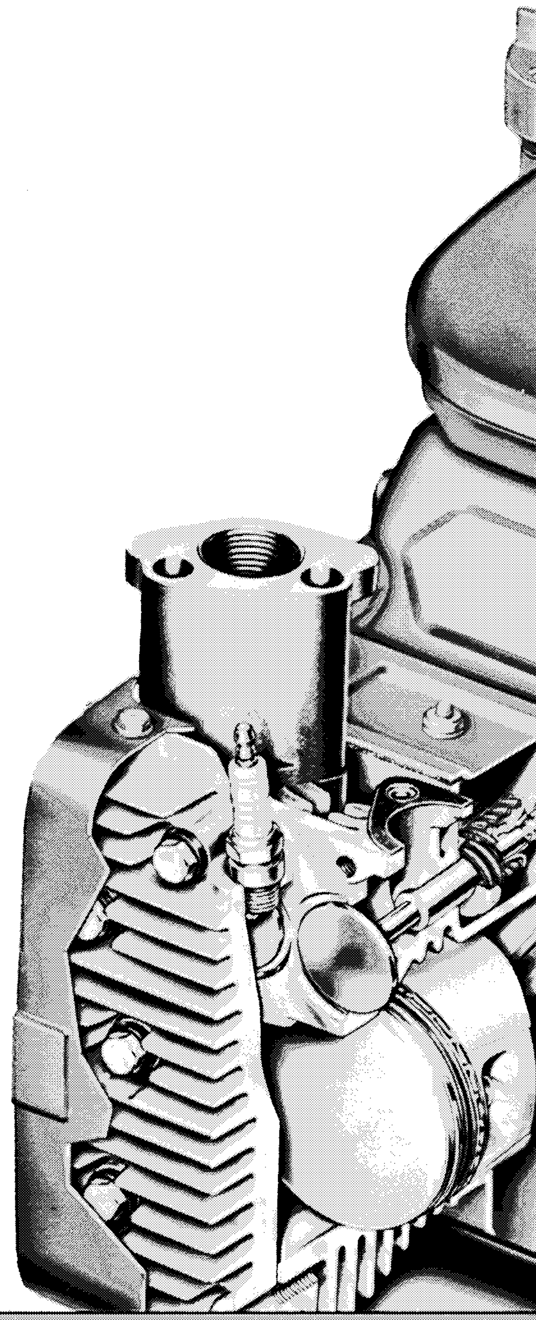
CYLINDER BORE

	CYLINDER 1	CYLINDER 2
Bore Scored	☐	☐
Worn	☐	☐
Not Damaged	☐	☐
Others		

Maximum Wear Spec.

	CYLINDER 1 X	CYLINDER 1 Y	CYLINDER 2 X	CYLINDER 2 Y	MAX. OUT OF ROUND
Top					
Center					
Bottom					
Max. Taper					

3



KOHLER engines

ENGINE DIVISION, KOHLER CO., KOHLER, WISCONSIN 53044

FORM NO.:	TP-2150-A
ISSUED:	9/83
REVISED:	9/89
MAILED:	

LITHO IN U.S.A.

KOHLER® COMMAND PRO

Power and Performance on Demand.

V-TWINS

KOHLER Command PRO® 17-28 HP air-cooled, vertical- and horizontal-shaft, V-twin engines.

KOHLER® engines

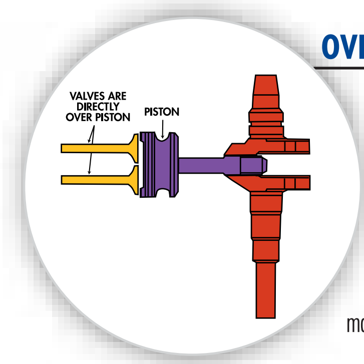
BORN TO RUN™

SPECIALLY DESIGNED OIL COOLER

All KOHLER® Command PRO 17-28 HP vertical and 18-28 HP horizontal models have a plate-type oil cooler. It maintains the lowest possible oil temperature during the entire power range, regardless of application or duty cycle. It also protects the environment by extending oil change intervals.

ELECTRONIC FUEL INJECTION (EFI)

The Command PRO® 26 HP and 28 HP engines include electronic fuel injection. EFI provides consistent starting, reliable throttle response and superior fuel economy. Specs can also be customized for a complete vehicle management system.

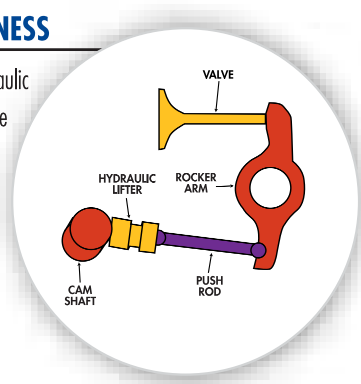


OVERHEAD VALVE EFFICIENCY

Command PRO valves are positioned directly over the piston, providing greater volumetric efficiency and a higher compression ratio. This means you get virtually no carbon buildup, increased power, improved fuel economy and cooling, as well as reduced oil consumption. The result? Reduced maintenance costs.

HYDRAULIC VALVE SMOOTHNESS

KOHLER Command PRO engines feature hydraulic valve lifters. Oil-pressurized valve lifters ensure that push rods remain in constant contact with rocker arms, eliminating valve adjustment. This makes the Command PRO valve train nearly maintenance free.



ELECTRONIC IGNITION

Command PRO models have electronic ignition for a stronger spark at low cranking speed. This means faster, all-weather starts – even at temperatures as low as -20 degrees F.

LONG ENGINE LIFE

Built in the U.S.A., Command PRO engines utilize only the finest quality components. An induction-hardened crankshaft, long-life cylinder liners, valve seats of high chromium/tungsten alloys and Stellite® exhaust valves contribute to long engine life. KOHLER Step-Lock™ connecting rods are precisely aligned for superior bearing lubrication. What's more, the Command PRO design employs special cam-ground, contoured pistons.

QUIET PERFORMANCE

The KOHLER exclusive, whisper-quiet hydraulic valve lifters, engineered material blower housing, helical gears and available mufflers make Command PRO twins the industry standard for quiet performance.

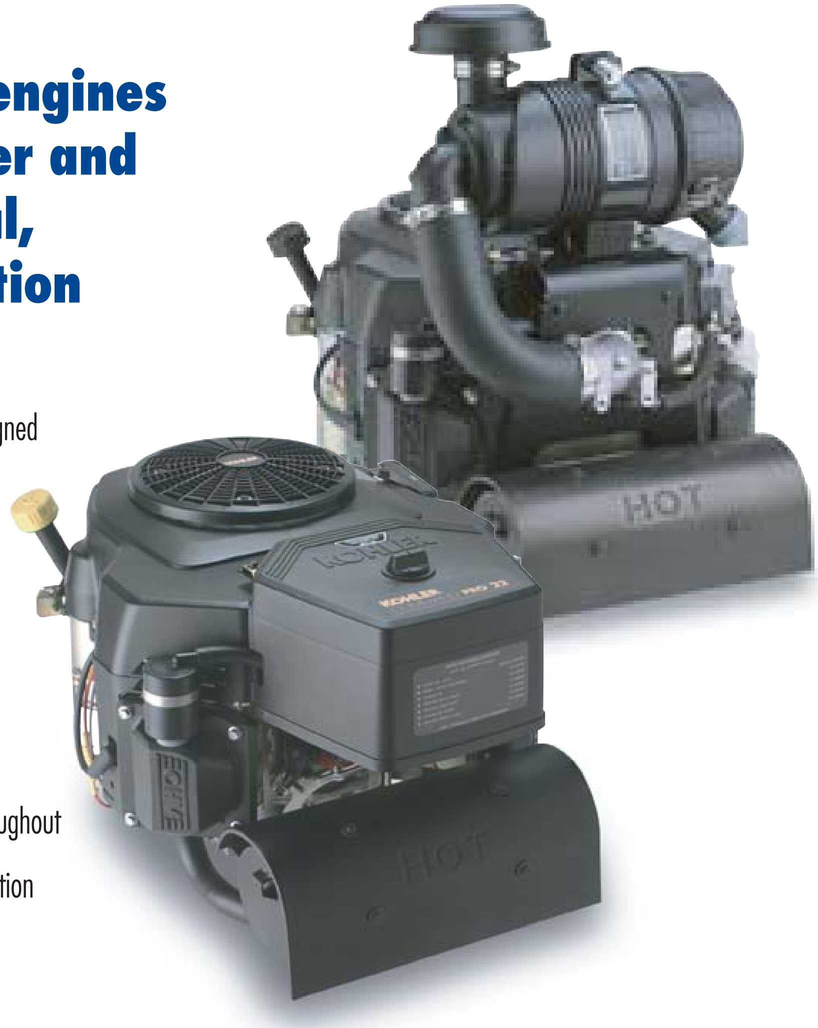
CONVENIENT MAINTENANCE

The easy-access, large-capacity air cleaner and pre-cleaner provide maximum protection. Command PRO twins require only 100-hour oil changes under normal running conditions and 200-hour filter changes. The spin-on oil filter and convenient oil fill and drain locations make changes quick and easy. Electronic ignition and hydraulic valve lifters are maintenance free for the life of the engine. And the OHV design eliminates decarboning.

TWO-YEAR WARRANTY

KOHLER engines are backed by nearly 13,000 dealers and distributors worldwide, and a two-year limited warranty covering both consumer and commercial applications. When you specify KOHLER engines, you're getting the best.

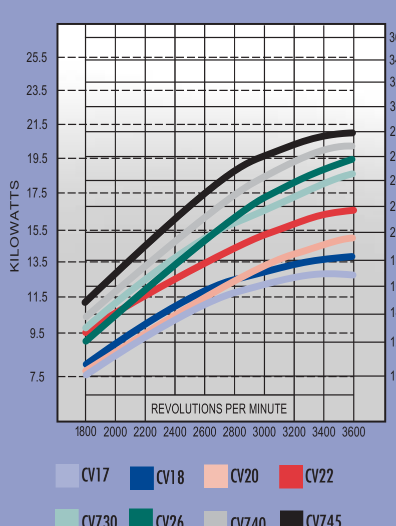
KOHLER Command PRO® engines deliver exceptional power and performance in industrial, commercial and construction equipment applications.



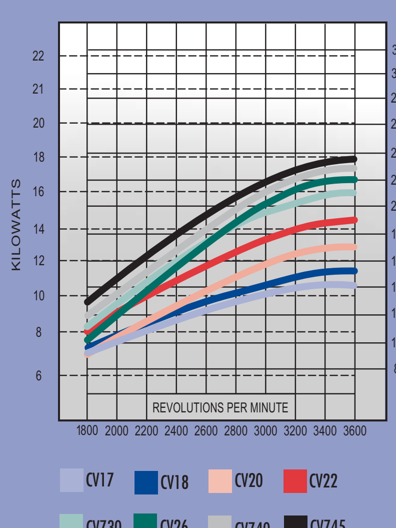
Made in the U.S.A., KOHLER Command PRO engines are designed to excel in normal or extreme conditions in a wide range of situations, including industrial/commercial and construction equipment applications.

With full-pressure lubrication, long-life cylinder liners and the proven KOHLER overhead valve design, your Command PRO vertical-shaft V-twin will deliver the horsepower you need throughout its long life. The CV26 and CV745 include electronic fuel injection (EFI) for superior fuel economy.

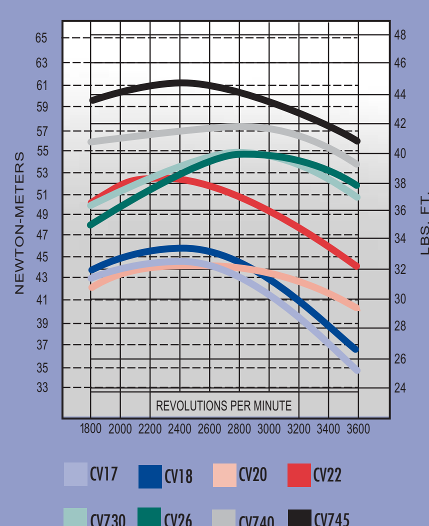
MAXIMUM POWER



RECOMMENDED POWER



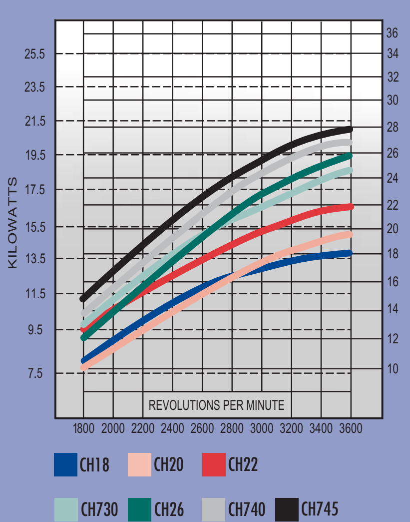
MAXIMUM TORQUE



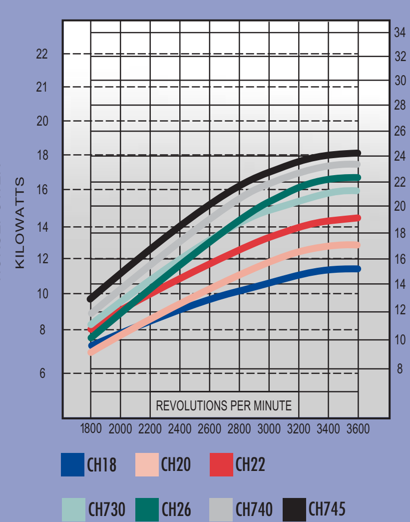
KOHLER Command PRO® engines ensure total performance in a user-friendly, environmentally safe package.

KOHLER Command PRO horizontal-shaft V-twins are designed to address the environmental challenges of the next century. Command PRO engines comply with both exhaust emissions and sound standards. CO, HC and Nox emissions meet California and EPA standards – while Command PRO's environmentally friendly, quiet power meets strict European sound standards. And the CH26 and CH745 include electronic fuel injection (EFI) for superior fuel economy.

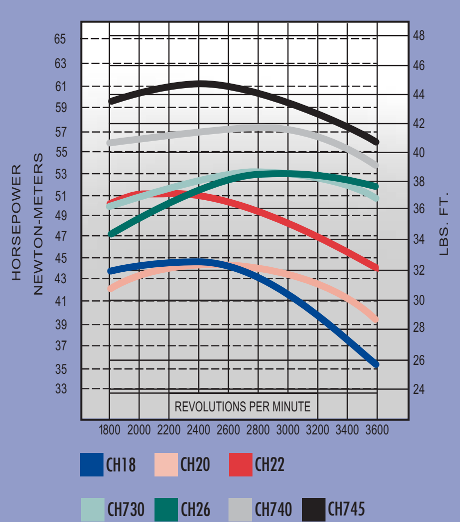
MAXIMUM POWER



RECOMMENDED POWER



MAXIMUM TORQUE



THE BENEFITS OF CHOOSING A HORIZONTAL-SHAFT KOHLER COMMAND PRO® ENGINE:

EASY, DEPENDABLE STARTS

- A 12V solenoid shift starter
- B Electronic ignition system, high performance spark plugs (PRO)
- C Mechanical fuel pump

RELIABILITY & LONG-LIFE DESIGN

- D Cast iron cylinder liners
- E PTO thrust bearings (25-28 hp) PRO
- F Hardened crankshaft journals (PRO)
- G Stellite® exhaust valves with inserts & rotators (PRO)
- H Hydraulic valve system
- I Full-pressure lubrication with full-flow filter
- J High efficiency oil cooler (std. 25-28 hp)
- K Oil Sentry™ low-oil warning system
- L Large capacity, dual-element air filter (PRO)

PEAK POWER & PERFORMANCE

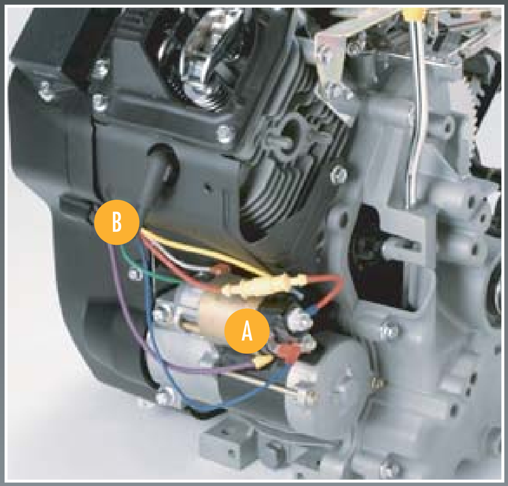
- M Overhead valve design
- N Closed breather system
- O Large capacity, in-line fuel filter (PRO)
- P SMART-CHOKE™ carburetor with accelerator pump (PRO)

QUIET, SMOOTH OPERATION

- Q Variable speed, mechanical governor
- R Fuel shutdown solenoid

USER-FRIENDLY MAINTENANCE

- S Yellow oil cap & dipstick (PRO)
- T Dual oil drains



Features & Benefits

Specifications

ENGINE TYPE	Four-cycle, V-twin cylinder, air-cooled, vertical- and horizontal-shaft, gasoline, full-pressure lubrication with oil filter, aluminum head and crankcase with cast iron cylinder liners.							
Model	**CV17**	**CH/CV18**	**CH/CV20**	**CH/CV22**	**CH/CV730**	**CH/CV26**	**CH/CV740**	**CH/CV745**
Power* @ 3600 rpm: Max - hp (kW) Recommended - hp (kW)	17 (12.7) 14.5 (10.8)	18 (13.4) 15.3 (11.4)	20 (14.9) 17 (12.7)	22 (16.4) 18.7 (13.9)	25 (18.6) 21.3 (15.9)	26 (19.4) 22.1 (16.5)	27 (20.1) 23 (17.2)	28 (20.9) 23.8 (17.7)
Displacement: cu. in. (cc)	34 (561)	38 (624)	38 (624)	41 (674)	44 (725)	44 (725)	44 (725)	44 (725)
Bore: in. (mm)	2.9 (73)	3.0 (77)	3.0 (77)	3.2 (80)	3.3 (83)	3.3 (83)	3.3 (83)	3.3 (83)
Stroke: in. (mm)	2.6 (67)	2.6 (67)	2.6 (67)	2.6 (67)	2.6 (67)	2.6 (67)	2.6 (67)	2.6 (67)
Peak Torque @ Maximum: lbs.ft.	31.7 @ 2000	32.8 @ 2200	32.6 @ 2600	38.2 @ 2200	39.9 @ 2800	40 @ 2800	42.7 @ 3000	44.8 @ 2200
Compression Ratio:	8.5:1	8.5:1	8.5:1	8.5:1	9:1	9:1	9:1	9:1
Dry Weight: lbs. (kg)	90 (41)	90 (41)	90 (41)	90 (41)	94 (43)	94 (43)	94 (43)	94 (43)
Oil Capacity w/filter: U.S. qts. (L)	2 (1.9)	2 (1.9)	2 (1.9)	2 (1.9)	2.1 (2)	2.1 (2)	2.1 (2)	2.1 (2)
Dimensions: L x W x H in. (mm)	b	a/b	a/b	a/b	a/b	a/b	a/b	a/b
a = CH**	flat air cleaner: 13.8 (351) x 17.7 (451) x 19.0 (483) heavy-duty air cleaner: 13.8 (351) x 17.7 (451) x 26.5 (672)							
b = CV***	flat air cleaner: 18.2 (462) x 17.7 (451) x 14.1 (358) (not shown) commercial mower air cleaner: 21.2 (538) x 17.7 (451) x 14.3 (363) heavy-duty air cleaner: 19.0 (483) x 17.7 (451) x 22.5 (572)							

* Horsepower ratings are in accordance with Society of Automotive Engineers Small Engine Test Code J1995. Actual engine horsepower is lower and affected by, but not limited to, accessories (air cleaner, exhaust, charging, cooling, fuel pump, etc.), application, engine speed and ambient operating conditions (temperature, humidity and altitude). For more information, contact Kohler Co. Engine Engineering. Kohler reserves the right to change product specifications, designs and equipment without notice and without incurring obligation.

** L = grass screen to PTO mounting face W = spark plug to spark plug H = top of air cleaner cover to mounting feet

*** L = blower housing to air cleaner cover W = spark plug to spark plug H = top of air cleaner cover to mounting feet

STANDARD FEATURES (BASIC ENGINES)

- **Accelerator pump (CH730, CV17-740)**
- **Electronic fuel injection (CH/CV26, 745)**
- **20 A charging, regulated**
- **High-performance spark plugs**
- **Top-mount controls (CV17-745)**
- **High-efficiency fan & screen**
- **Yellow oil cap and dipstick**
- **Commercial mower package (CV17-745)**
- **Large filters (air, oil, fuel)**
- **Hardened crank journals**
- **Oil cooler (CH22-745, CV17-745)**
- Hydraulic valve lifters
- Mechanical fuel pump (CH)
- Pulse fuel pump (CV)
- SMART-CHOKE™ carburetor
- 12 V electric start
- Dual-element air cleaner
- Dual oil drains
- Electronic ignition
- Solenoid fuel shutdown
- Oil Sentry™ (installed, not wired)
- Full-pressure lubrication/full flow filter
- PTO thrust bearing (CH730-745)
- PTO side-load bearing (CV730-745)

Features shown in **bold** are exclusive to Command PRO® engines. Features shown in regular type are standard on both Command and Command PRO engines.

POPULAR FACTORY OPTIONS

- Remote oil filter
- Rotatable oil filter base
- Muffler guard
- Variety of mufflers
- Exhaust deflector/spark arrestor
- Engine-mounted controls (CH)
- 5% Governor
- Electronic Governor
- SAE A/B pump mounts
- Choice of air cleaners (flat, H.D., WAWB)
- 15 & 25 A charging systems
- Guard for rotating grass screen
- Chopper-type grass screen
- Additional crank sizes
- Pulse fuel pump (CH)
- Flywheel PTO's
- LP and dual fuel carburetor (CH20/730)
- PTO side-load bearing (CH730-745)

ISO 9001 SGS
Certification #US97/0977

FOR MORE INFORMATION, CONTACT YOUR KOHLER SOURCE OF SUPPLY OR CALL TOLL FREE IN THE U.S. AND CANADA **1-800-544-2444.**

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