Producto: TRACK-TYPE TRACTOR
Modelo: D8L TRACK-TYPE TRACTOR 53Y
Configuración: D8L TRACTOR 53Y00001-UP (MACHINE) POWERED BY 3408 ENGINE

Pruebas y Ajustes
3408 ENGINE FOR CATERPILLAR BUILT MACHINES
Número de medio -SENR2333-02 **Fecha de publicación -01/08/1993** **Fecha de actualización -11/10/2001**

Testing and Adjusting

Introduction

NOTE: For Specifications with illustrations, make reference to Specifications For 3408 Engine For Caterpillar Built Machines, Form No. SENR2332. If the Specifications in Form SENR2332 are not the same as in the Systems Operation and the Testing And Adjusting, look at the printing date on the back cover of each book. Use the Specifications given in the book with the latest date.

Troubleshooting

Troubleshooting can be difficult. The Troubleshooting Index gives a list of possible problems. To make a repair to a problem, make reference to the cause and correction on the pages that follow.

This list of problems, causes, and corrections will only give an indication of where a possible problem can be, and what repairs are needed. Normally, more or other repair work is needed beyond the recommendations in the list.

Remember that a problem is not normally caused only by one part, but by the relation of one part with other parts. This list is only a guide and can not give all possible problems and corrections. The serviceman must find the problem and its source, then make the necessary repairs.

Troubleshooting Problem List

1. Engine Will Not Turn When Start Switch Is On.
2. Engine Will Not Start.
3. Engine Misfires Or Runs Rough.
4. Stall At Low rpm.
5. Sudden Changes In Engine RPM.
6. Not Enough Power.
7. Too Much Vibration.
8. Loud Combustion Noise.
9. Valve Train Noise (Clicking).
10. Oil In Cooling System.
11. Mechanical Noise (Knock) In Engine.
12. Fuel Consumption Too High.
13. Loud Valve Train Noise.
14. Too Much Valve Lash.
15. Valve Rotocoil Or Spring Lock Is Free.
16. Oil At The Exhaust.

17. Little Or No Valve Lash.
18. Engine Has Early Wear.
19. Coolant In Lubrication Oil.
20. Too Much Black Or Gray Smoke.
21. Too Much White Or Blue Smoke.
22. Engine Has Low Oil Pressure.
23. Engine Uses Too Much Lubrication Oil.
24. Engine Coolant Is Too Hot.
25. Exhaust Temperature Is Too High.
26. Starter Motor Does Not Turn.
27. Alternator Gives No Charge.
28. Alternator Charge Rate Is Low Or Not Regular.
29. Alternator Charge Rate Is Too High.
30. Alternator Has Noise.

Troubleshooting Problems

Problem 1. Engine Crankshaft Will Not Turn When Start Switch Is On

Probable Cause:

1. Battery Has Low Output

Make Reference to Item 26.

2. Wires Or Switches Have Defect

Make Reference to Item 26.

3. Starter Motor Solenoid Has A Defect

Make Reference to Item 26.

4. Starter Motor Has A Defect

Make Reference to Item 26.

5. Inside Problem Prevents Engine Crankshaft From Turning

If the crankshaft can not be turned after the driven equipment is disconnected, remove the fuel nozzles and check for fluid in the cylinders while the crankshaft is turned. If fluid in the cylinders is not the problem, the engine must be disassembled to check for other inside problems. Some of these inside problems are bearing seizure, piston seizure, wrong pistons installed in the engine, and valves making contact with pistons.

Problem 2. Engine Will Not Start

Probable Cause:

1. Starter Motor Turns Too Slow

Make Reference to Items 26 and 27.

2. Dirty Fuel Filter

Install new fuel filter.

3. Dirty Or Broken Fuel Lines

Clean or install new fuel lines as necessary.

4. Fuel Transfer Pump

At starting rpm, the minimum fuel pressure from fuel transfer pump must be 35 kPa (5 psi). If fuel pressure is less than 35 kPa (5 psi), change the fuel filter element. Look for air in the fuel system. If fuel pressure is still low, install a new fuel transfer pump.

5. No Fuel To Cylinders

Put fuel in fuel tank. "Prime" (remove the air and/or low quality fuel) the fuel system.

6. Poor Quality Fuel

Remove the fuel from the fuel tank. Install a new fuel filter element. Put a good grade of clean fuel in the fuel tank. See Fuels For Caterpillar Diesel Engines, Special Instruction, Form No. SEHS7067 and Measuring Diesel Fuel AP1 Specific Gravity, Special Instruction, Form No. GMG00977.

7. Wrong Fuel Injection Timing

Make adjustment to timing.

Problem 3. Engine Misfires Or Runs Rough

Probable Cause:

1. Fuel Pressure Is Low

Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system, sticking, binding or defective fuel bypass valve. Check fuel pressure. The outlet pressure of the fuel transfer pump is 230 ± 35 kPa (33 ± 5 psi) at full load speed.

If fuel pressure is lower than 140 kPa (20 psi), install a new filter element. If fuel pressure is still low, install a new fuel transfer pump.

2. Air In Fuel System

Find the air leak in the fuel system and correct it. If air is in the fuel system, it will probably get in on the suction side of fuel transfer pump.

3. Leak Or Break In Fuel Line Between Injection Pump And Injection Nozzle

Install a new fuel line.

4. Wrong Valve Lash

Make adjustment according to the Subject, Valve Lash Setting.

5. Defect in Fuel Injection Nozzle(s) or Injection Pump(s)

Run at rpm that causes engine to misfire the most or run the roughest. Then loosen a fuel injection line nut at the valve cover base for each cylinder, one at a time. Find the cylinder where a loosened fuel line nut does not change the way the engine runs. Test the injection pump and injection nozzle for that cylinder. Install new parts where needed.

6. Wrong Fuel Injection Timing

Make adjustment to timing.

7. Bent Or Broken Push Rod

Replacement of push rod is necessary.

8. Fuel Has "Cloud Point" Higher Than Atmospheric Temperature ("Cloud Point" = Temperature Which Makes Wax Form In Fuel.)

Drain the fuel tank, lines, and fuel injection pump housing. Change the fuel filter. Fill the tank with fuel which has the correct "cloud point" and remove the air from the system with the priming pump.

Problem 4. Stall At Low RPM

Probable Cause:

1. Fuel Pressure Is Low

Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system, sticking, binding or defective fuel bypass valve. Check fuel pressure. The outlet pressure of the fuel transfer pump is 230 ± 35 kPa (33 ± 5 psi) at full load speed.

If fuel pressure is lower than 140 kPa (20 psi), install a new filter element. If fuel pressure is still low, install a new fuel transfer pump.

2. Idle RPM Too Low

Make adjustment to governor so idle rpm is the same as given in the Fuel Setting And Related Information Fiche.

3. Defect In Fuel Injection Nozzle(s)

Install a new fuel injection nozzle(s).

4. Engine Accessories

Check engine accessories for damage and correct adjustment. If necessary, disconnect the accessories and test the engine.

5. Defect In Fuel Injection Pump(s)

Install new parts if needed.

Problem 5. Sudden Changes In Engine Speed (RPM)

Probable Cause:

1. Failure of Governor or Fuel Injection Pump

Look for damaged or broken springs, linkage or other parts. Remove the governor. Check for free travel of the fuel racks. Be sure fuel injection pumps are installed correctly. Check for correct governor spring. Install new parts for those that have damage or defects.

Problem 6. Not Enough Power

Probable Cause:

1. Poor Quality Fuel

Remove the fuel from the fuel tank. Install a new fuel filter element. Put a good grade of clean fuel in the fuel tank.

2. Fuel Pressure Is Low

Make sure there is fuel in the fuel tank. Look for leaks or bad bends in the fuel line between fuel tank and fuel transfer pump. Look for air in the fuel system, sticking, binding or defective fuel bypass valve. Check fuel pressure. The outlet pressure of the fuel transfer pump is 230 ± 35 kPa (33 ± 5 psi) at full load speed.

If fuel pressure is lower than 140 kPa (20 psi), install a new fuel filter element. If fuel pressure is still low, install a new fuel transfer pump.

3. Leaks In Air Inlet System

Check the pressure in the air inlet manifold. Look for restrictions in the air cleaner.

4. Governor Linkage

Make adjustment to get full travel of linkage. Install new parts for those that have damage or defects.

5. Wrong Valve Lash

Make adjustment according to the Subject, Valve Lash Setting.

6. Defect In Fuel Injection Nozzle(s) Or Fuel Injection Pump(s)

Run at rpm that causes engine to misfire the most or run the roughest. Then loosen a fuel line nut on the injection pump for each cylinder, one at a time. Find the cylinder where a loosened fuel line nut does not change the way the engine runs. Test the injection pump and injection nozzle for that cylinder. Install new parts where needed.

7. Wrong Fuel Injection Timing

Make adjustment to timing.

8. Rack Setting Too Low

Make reference to the Fuel Setting And Related Information Fiche.

9. Fuel Ratio Control

Control either needs an adjustment or it is damaged and a new control is needed.

10. Turbocharger Has Carbon Deposit Or Other Causes Of Friction

Inspect and repair turbocharger as necessary.

Problem 7. Too Much Vibration

Probable Cause:

1. Loose Bolt Or Nut For Pulley Or Damper

Tighten bolt or nut.

2. Pulley Or Damper Has A Defect

Install a new pulley or damper.

3. Engine Supports Are Loose, Worn, Or Have A Defect

Tighten all bolts that hold engine supports. Install new components if necessary.

4. Engine Misfires Or Runs Rough

Make Reference to Item 3.

5. Fan Blade Not In Balance

Loosen or remove fan belts and operate engine for a short time at the rpm that the vibration was present. If vibration is not still present, make a replacement of the fan assembly.

Problem 8. Loud Combustion Noise (Sound)

Probable Cause:

1. Poor Quality Fuel

Remove the fuel from the fuel tank. Install a new fuel filter element. Put a good grade of clean fuel in the fuel tank. See Fuels For Caterpillar Diesel Engines, Special Instruction, Form No. SEHS7067 and Measuring Diesel Fuel AP1 Specific Gravity, Special Instruction, Form No. GMG00977.

2. Defect In Fuel Injection Nozzle(s)

Install new fuel injection valve(s).

3. Defect In Fuel Injection Pump(s)

Install new fuel injection pump(s).

4. Wrong Fuel Injection Timing

Make adjustment to timing.

Problem 9. Valve Train Noise (Clicking)

Probable Cause:

1. Damage To Valve Spring(s), Locks, Or Broken Or Worn Valve Lifter

Install new parts where necessary. Broken locks can cause the valve to get into the cylinder. This will cause much damage.

2. Not Enough Lubrication

Check lubrication in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow of oil at low rpm. Oil passages must be clean, especially those that send oil to the cylinder head.

3. Too Much Valve Lash

Make adjustment according to the Subject, Valve Lash Setting.

Problem 10. Oil In Cooling System

Probable Cause:

1. Defect In Core Of Engine Oil Cooler Or Transmission Oil Cooler

Install a new engine oil cooler or transmission oil cooler. Drain and flush cooling system and refill with new coolant.

2. Defect In Spacer Plate Gasket

Install new spacer plate gasket.

3. Failure Of Cylinder Head Gasket

Install a new head gasket.

Problem 11. Mechanical Noise (Knock) In Engine

Probable Cause:

1. Failure Of Bearing For Connecting Rod

Inspect the bearing for the connecting rod and the bearing surface (journal) on the crankshaft. Install new parts where necessary.

2. Damaged Timing Gears

Install new parts where necessary.

3. Damaged Crankshaft

Make replacement of the crankshaft.

4. Defect In Attachment

Repair or install new components.

Problem 12. Fuel Consumption Too High

Probable Cause:

1. Fuel System Leaks

Large changes in fuel consumption may be the result. Inside leaks probably will cause low engine oil pressure and an increase in oil level in the engine. Tighten loose connections or make a replacement of the component that leaks.

2. Fuel And Combustion Noise (Knock)

Make Reference to Item 3 and Item 6.

3. Wrong Fuel Injection Timing

Make adjustment to timing.

Problem 13. Loud Valve Train Noise

Probable Cause:

1. Damage To Valve Spring(s)

Make replacement of parts with damage.

2. Damage To Camshaft

Make replacement of parts with damage. Clean engine thoroughly. If replacement of camshaft is made, new valve lifters are also necessary.

3. Damage To Valve Lifter

Clean engine thoroughly. Make a replacement of the damaged valve lifters. Inspect camshaft lobes for damage. Look for valves that do not move freely. Make an adjustment to valve lash according to the Subject, Valve Lash Setting.

4. Damage To Bridge For Valves Or Bridge Dowel

Make a replacement of the bridge and/or bridge dowel, and adjust as necessary.

Problem 14. Too Much Valve Lash

Probable Cause:

1. Not Enough Lubrication

Check lubrication in valve compartment. There must be a strong flow of oil at engine high rpm, but only a small flow at low rpm. Oil passages must be clean, especially those that send oil to the cylinder head.

2. Rocker Arm Worn At Face That Makes Contact With Bridge

If there is too much wear, install new parts or rocker arms. Make adjustment of valve lash according to the Subject, Valve Lash Setting.

3. Bridge Or Bridge Dowel For Valves Worn

Make replacement of the bridge and/or bridge dowel, and adjust as necessary.

4. End Of Valve Stem Worn

If there is too much wear, install new valves. Make adjustment to valve lash according to the Subject, Valve Lash Setting.

5. Worn Push Rods

If there is too much wear, install new push rods. Make adjustment of valve lash according to the Subject, Valve Lash Setting.

6. Broken Or Worn Valve Lifters

Install new valve lifters. Check camshaft for wear. Check for free movement of valves or bent valve stem. Clean engine thoroughly. Make adjustment of valve lash according to the Subject, Valve Lash Setting.

7. Worn Camshaft Lobes

Install a new camshaft. Install new valve lifters if damaged. Check for free movement of valves or bent valve stems. Make adjustment of valve lash according to the Subject, Valve Lash Setting.

Problem 15. Valve Rotocoil Or Spring Lock Is Free

Probable Cause:

1. Broken Locks

Broken locks can cause the valve to get into the cylinder. This will cause much damage.

2. Broken Valve Spring(s)

Install new valve spring(s).

3. Broken Valve

Replace valve and other damaged parts.

Problem 16. Oil At The Exhaust

Probable Cause:

1. Too Much Oil In The Valve Compartment

Look at both ends of the rocker arm shaft. Be sure a plug is in each end of the shaft.

2. Worn Valve Guides

Reconditioning of the cylinder head is needed.

3. Worn Piston Rings

Inspect and install new parts as needed.

Problem 17. Little Or No Valve Lash

Probable Cause:

1. Worn Valve Seat Or Face Of Valve

Reconditioning of cylinder head is needed. Make adjustment of valve lash according to the Subject, Valve Lash Setting.

Problem 18. Engine Has Early Wear

Probable Cause:

1. Dirt In Lubrication Oil

Remove dirty lubrication oil. Install new oil filter elements. Put clean oil in the engine.

2. Air Inlet Leaks

Inspect all gaskets and connections. Make repairs if leaks are found.

3. Fuel Leakage Into Lubrication Oil

This will cause high fuel consumption and low engine oil pressure. Make repairs if leaks are found. Install new parts where needed.

Problem 19. Coolant In Lubrication Oil

Probable Cause:

1. Failure Of Engine Oil Cooler Core

Install a new engine oil cooler. Drain crankcase and refill with clean engine oil. Install new oil filter elements.

2. Failure of Cylinder Head Gasket Or Water Seals

Check cylinder liner projection. Install a new spacer plate gasket and new water seals in the spacer plate. Install a new cylinder head gasket. Tighten the bolts that hold the cylinder head according to the Specifications.

3. Crack Or Defect In Cylinder Head

Install a new cylinder head.

4. Crack Or Defect In Cylinder Block

Install a new cylinder block.

5. Failure Of Liner Seals

Replace seals.

6. Crack Or Defect In Cartridge Of Turbocharger

Install a new turbocharger cartridge.

Problem 20. Too Much Black Or Gray Smoke

Probable Cause:

1. Not Enough Air For Combustion

Check air cleaner for restrictions.

2. Damaged Fuel Injection Nozzle(s)

Install new fuel injection nozzle(s).

3. Wrong Fuel Injection Timing

Make adjustment to timing.

4. Defect In Fuel Ratio Control

Make adjustment to or install new control.

Problem 21. Too Much White Or Blue Smoke

Probable Cause:

1. Too Much Lubrication Oil In Engine

Remove extra oil. Find where extra oil comes from. Put correct amount of oil in engine.

2. Engine Misfires Or Runs Rough

Make Reference to Item 3.

3. Wrong Fuel Injection Timing

Make adjustment to timing.

4. Worn Valve Guides

Reconditioning of cylinder head is necessary.

5. Worn Piston Rings

Install new piston rings. Check condition of cylinder liners.

6. Failure Of Turbocharger Oil Seal

Check inlet manifold for oil. Replace seals and repair turbocharger if necessary.

7. Coolant In Combustion System

Check for cracked head.

Problem 22. Engine Has Low Oil Pressure

Probable Cause:

1. Dirty Oil Filter Or Oil Cooler

Check the operation of bypass valve for the filter. Install new oil filter elements if needed. Clean or install new oil cooler core. Remove dirty oil from engine. Put clean oil in engine.

2. Diesel Fuel In Lubrication Oil

Find the place where diesel fuel gets into the lubrication oil. Make repairs as needed. Remove the lubrication oil that has diesel fuel in it. Install new oil filter elements. Put clean oil in the engine.

3. Too Much Clearance Between Rocker Arm Shaft and Rocker Arms

Check lubrication in valve compartment. Install new parts as necessary.

4. Oil Pump Suction Pipe Has A Defect

Replacement of pipe is necessary.

5. Relief Valve For Oil Pump Does Not Operate Correctly

Clean valve and housing. Install new parts as necessary.

6. Oil Pump Is Worn Or Has A Defect

Repair or make replacement of necessary parts.

7. Too Much Clearance Between Crankshaft And Crankshaft Bearings

Inspect crankshaft and bearings. Install new parts as necessary.

8. Too Much Clearance Between Camshaft And Camshaft Bearings

Install new camshaft bearings. Install new camshaft if necessary.

9. Defect In Oil Pressure Gauge

Install new gauge.

10. Too Much Bearing Clearance For Idler Gear

Inspect bearings and make replacement as necessary.

Problem 23. Engine Uses Too Much Lubrication Oil

Probable Cause:

1. Too Much Lubrication Oil In Engine

Remove extra oil. Find where extra oil comes from. Put correct amount of oil in engine.

2. Oil Leaks

Find all oil leaks. Make repairs as necessary.

3. Oil Temperature Is Too High

Check operation of engine oil cooler. Clean the core of the engine oil cooler. Install new parts if necessary.

4. Too Much Oil In the Valve Compartment

Look at both ends of the rocker arm shaft. Be sure a plug is in each end of the shaft.

5. Worn Valve Guides

Reconditioning of the cylinder head is necessary.

6. Worn Piston Rings And Cylinders

Inspect and install new parts as necessary. Reconditioning of the cylinder block may be necessary.

7. Failure Of Seal Rings In Turbocharger

Check inlet manifold for oil and make repair to turbocharger if necessary.

Problem 24. Engine Coolant Is Too Hot

Probable Cause:

1. Restriction To Flow of Coolant Through Radiator Core Tubes

Clean and flush radiator.

2. Restriction to Air Flow Through Radiator

Remove all restrictions to air flow.

4. Low Fan Speed

Check for worn or loose fan belts.

5. Not Enough Coolant In System

Add coolant to cooling system.

6. Pressure Relief Valve Has A Defect

Check operation of pressure relief valve. Install a new pressure relief valve if necessary.

7. Combustion Gases In Coolant

Find out where gases get into the cooling system. Make repairs as necessary.

8. Water Temperature Regulators (Thermostats) Or Temperature Gauge Has A Defect

Check water temperature regulators for correct operation. Check temperature gauge operation.

Install new parts as necessary.

9. Water Pump Has A Defect

Make repairs or replacement of the water pump as necessary.

10. Too Much Load On The System

Make a reduction to the load.

11. Wrong Fuel Injection Timing

Make adjustment to timing.

12. Torque Converter Or Transmission Does Not Operate Correctly. This Can Cause An Increase In The Coolant Temperature

Make corrections for torque converter or transmission running too hot.

Problem 25. Exhaust Temperature Is Too High

Probable Cause:

1. Air Inlet Or Exhaust System Has A Restriction

Remove restriction.

2. Wrong Fuel Injection Timing

Make an adjustment to the timing.

Problem 26. Starter Motor Does Not Turn

Probable Cause:

1. Battery Has Low Output

Check condition of battery. Charge battery or make replacement as necessary.

2. Wires Or Switch Has Defect

Make repairs or replacement as necessary.

3. Starter Motor Solenoid Has A Defect

Install a new solenoid.

4. Starter Motor Has A Defect

Make repair or replacement of starter motor.

Problem 27. Alternator Gives No Charge

Probable Cause:

1. Loose Drive Belt For Alternator

Make an adjustment to put the correct tension on the drive belt.

2. Charging Or Ground Return Circuit Or Battery Connections Have A Defect

Inspect all cables and connections. Clean and tighten all connections. Make replacement of parts with defect.

3. Rotor (Field Coil) Has A Defect

Install a new rotor.

Problem 28. Alternator Charge Rate Is Low Or Not Regular

Probable Cause:

1. Loose Drive Belt For Alternator

Make an adjustment to put the correct tension on the drive belt.

2. Charging Or Ground Return Circuit Or Battery Connections Have A Defect

Inspect all cables and connections. Clean and tighten all connections. Make replacement of parts with defect.

3. Alternator Regulator Has A Defect

Install a new alternator regulator.

4. Alternator Regulator Not Adjusted Correctly

See Electrical System in Testing and Adjusting. Some alternator regulators can be adjusted and some can not be adjusted.

5. Rectifier Diodes Have A Defect

Make replacement of rectifier diode that has a defect.

6. Rotor (Field Coil) Has A Defect

Install a new rotor.

Problem 29. Alternator Charge Rate Is Too High

Probable Cause:

1. Alternator Or Alternator Regulator Has Loose Connections

Tighten all connections to alternator or alternator regulator.

2. Alternator Regulator Has A Defect

Install a new alternator regulator.

Problem 30. Alternator Has Noise

Probable Cause:

1. Drive Belt For Alternator Is Worn Or Has A Defect

Install a new drive belt for the alternator.

2. Loose Alternator Drive Pulley

Check groove in pulley for key that holds pulley in place. If groove is worn, install a new pulley. Tighten pulley nut according to Specifications.

3. Drive Belt And Drive Pulley For Alternator Are Not In Alignment

Make an adjustment to put drive belt and drive pulley in correct alignment.

4. Worn Alternator Bearings

Install new bearings in the alternator.

5. Rotor Shaft Is Bent

Make a replacement of the rotor shaft.

6. Rectifiers In The Alternator Are Shorted

Make a replacement of the diode assembly.

Fuel System

Either too much fuel or not enough fuel for combustion can be the cause of a problem in the fuel system. Many times work is done on the fuel system when the problem is really with some other part of the engine. The source of the problem is difficult to find, especially when smoke comes from the exhaust. Smoke that comes from the exhaust can be caused by a defective unit injector, but it can also be caused by one or more of the reasons that follow:

a. Not enough air for good combustion.
b. An overload at high altitude.
c. Oil leakage into combustion chamber.
d. Not enough compression.
e. Fuel injection timing incorrect.

Fuel System Inspection

A problem with the components that send fuel to the engine can cause low fuel pressure. This can decrease engine performance.

1. Check the fuel level in the fuel tank. Look at the cap for the fuel tank to make sure the vent is not filled with dirt.

2. Check the fuel lines for fuel leakage. Be sure the fuel supply line does not have a restriction or a bad bend. Verify that the fuel return line has not collapsed in the sections subject to heat.

3. Install a new fuel filter. Clean the primary fuel filter.

4. To remove air from the fuel system, use the procedure that follows:

a. Use the priming pump to remove air from the low pressure side of the fuel system.

b. Loosen one-half turn the fuel injection line nuts at each adapter in the valve cover base. Move throttle lever to Low Idle position. Use the starter motor to turn the engine until fuel without air flows from the loose connections. Tighten the nuts.

NOTE: Because of the check assemblies in the injection pump outlets for the DI engine, the priming pump will not give enough pressure to remove air from the fuel injection lines.

5. Inspect the fuel bypass valve to see that there is no restriction to good operation.

Checking Engine Cylinders Separately

An easy check can be made to find the cylinder that runs rough (misfires) and causes black smoke to come out of the exhaust pipe.

Run the engine at the speed that is the roughest. Loosen the fuel line nut at a fuel injection pump. This will stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine performance. Be sure to tighten each fuel line nut after the test, before the next fuel line nut is loosened. Check each cylinder by this method. When a cylinder is found where the loosened fuel line nut does not make a difference in engine performance, test the injection pump and injection valve for that cylinder.

Temperature of an exhaust manifold port, when the engine runs at low idle speed, can also be an indication of the condition of a fuel injection valve. Low temperature at an exhaust manifold port is an indication of no fuel to the cylinder. This can possibly be an indication of an injection valve with a defect. Extra high temperature at an exhaust manifold port can be an indication of too much fuel to the cylinder, also caused by an injection valve with a defect.

The most common defects found with the fuel injection valves are:

1. Carbon on tip of the nozzle or in the nozzle orifice.
2. Orifice wear.
3. Dirty nozzle screen.

Fuel Injection Service

Injection Valve (Capsule-Type Nozzle)

Tools Needed		
5P0144	Socket	1
5P5195	Fuel Line Wrench	1
5P6229	Extractor	1

If a fuel injection nozzle has been removed from the direct injection adapter, test the nozzle before it is again installed in the adapter. See Testing Capsule-Type Fuel Injection Nozzles.

Make sure the contact surfaces of the nozzle and direct injection adapter are clean and smooth before installation of the nozzle. Tighten the nut that holds the nozzle in position to 75 ± 7 N·m (55 ± 5 lb ft).

NOTICE

The nut that holds the nozzle in position must have the correct torque. There will be damage to the nozzle if the nut is too tight. If the nut is not tight enough, the nozzle can leak.

Install the inner fuel injection line to the adapter and to the nozzle. Tighten nuts of both ends to 40 ± 7 N·m (30 ± 5 lb ft). Use the 5P0144 Socket to tighten the fuel line nut at the nozzle. Use 5P5195 Fuel Line Wrench to tighten fuel line nut at the adapter.

Removal of Injection Pump

Tools Needed		
6V6019	Timing Pin	1
8T5287	Wrench	1
8S2244	Extractor	1

1. Remove plug from fuel injection pump housing (2).

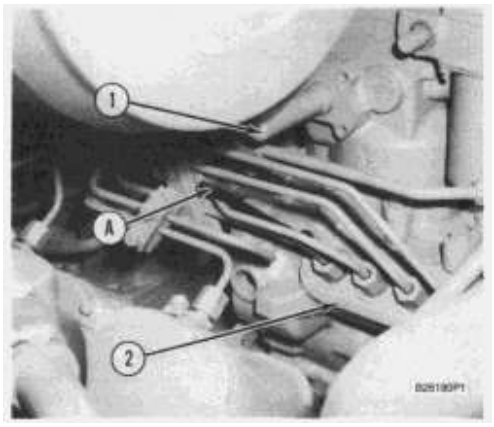
2. Install 6V6019 Timing Pin (A) with the flat end down in the hole that the plug was removed from.

3. Turn governor control shaft (1) toward High Idle and push down on timing pin (A) until it engages in the slot (groove) in the rack. The rack is now centered (at zero position). The fuel injection pumps can now be removed.

4. Disconnect the fuel lines from the injection pumps.

5. Use the 8T5287 Wrench to loosen the bushing that holds the fuel injection pump in the housing.

6. Install 8S2244 Extractor (5) on the threads of the injection pump. Pull the pump straight out of the bore.



Put Rack At Zero Position
(1) Governor control shaft. (2) Fuel injection pump housing. (A) 6V6019 Timing Pin.

When injection pumps and spacers are removed from the injection pump housing, keep the parts for each pump together so they can be installed back in their original location. Make reference to subject, Checking The Plunger And Lifter Washer On The Injection Pump.

Be careful when injection pumps are disassembled. Do not damage the surface on the plunger. The plunger and barrel for each pump are made as a set. Do not put the plunger of one pump in the barrel of another pump. If one part is worn, install a complete new pump assembly. Be careful when the plunger is put in the bore of the barrel.

Installation of Injection Pump

Tools Needed		
9S0240	Rack Position Tool Group or 6V9128 Rack Position Tool Group	1
6V6019	Timing Pin	1
8T5287	Wrench	1
8S2244	Extractor	1

NOTICE

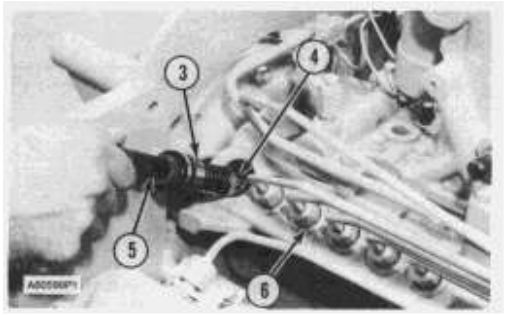
The fuel rack Must Be In The Center Position before the correct installation of an injection pump is possible.

The procedure to center the fuel rack is shown in the subject, Removal Of Injection Pump.

To install a fuel injection pump back into the housing bore, use the procedure that follows:

1. Put 8S2244 Extractor (5) on threads of injection pump.

2. Put groove of barrel (3) in alignment with slot of gear segment (4) (slot is on opposite side of gear segment teeth).



Fuel Pump Installation
(Typical Illustration) (3) Barrel. (4) Gear segment. (5) 8S2244 Extractor. (6) Bushing.

3. Look inside the bore of the injection pump housing to find the dowel. Put groove of the barrel in alignment with the dowel and put the injection pump straight down into the bore.

4. Push down on extractor (5) (hand force only) and install bushing (6) that holds the injection pump in

the pump housing. If the pump is in the correct position, the bushing will turn into the threads of the injection pump housing with the fingers until it is even with the top of the housing (except for the pump that is in the position to fire). When bushing is installed correctly, tighten the bushing to 205 ± 14 N·m (150 ± 10 lb ft).

NOTICE

Damage to the housing will be the result if the bushing is too tight. If the bushing is not tight enough, the pump will have leakage.

5. Remove the 6V6019 Timing Pin from injection pump housing and install the plug back in the hole.

6. Move the governor control back to shut-off position. Check to be sure governor control moves freely between fuel-on and shut-off position.

Check for the correct installation of injection pump with the engine stopped. Rack travel from the center position in the fuel-on direction can be checked with governor installed, but the governor and governor piston must be removed to check for full rack travel. Use 9S240 Rack Position Tool Group and the chart that follows to check rack travel. Make reference to Fuel Rack Setting for installation of 9S0240 Rack Position Tool Group.

EXAMPLE OF RACK TRAVEL

TEETH OFF	TOTAL RACK TRAVEL		TRAVEL FROM CENTER POSITION		TOTAL REDUCTION OF TRAVEL	
	mm	in.	mm	in.	mm	in.
0	20	.8	10	.4	0	0
1	15	.6	7	.3	5	.2

The same results can be obtained for 2 and 3 teeth off. Reduction of rack travel is greater but will not have a constant ratio.

A65355-1P1

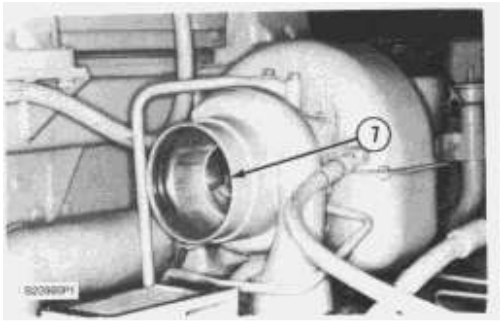
With the governor piston and valve removed, the total amount of fuel rack travel (from shut-off position to full load position) is approximately 20.32 mm (.800 in). If the pump is installed wrong (center tooth of gear segment is not in correct notch of fuel rack) fuel rack travel will be less than 20.32 mm (.800 in). The injection pump will have to be removed and then installed correctly.

WARNING

If one or more of the fuel injection pumps have been installed wrong, it is possible for the engine to run out of control when started. When any of the fuel injection pumps have been removed and installed with the fuel injection pump housing on the engine, take the precautions (steps) that follow to stop the engine if it starts to overspeed (run out of

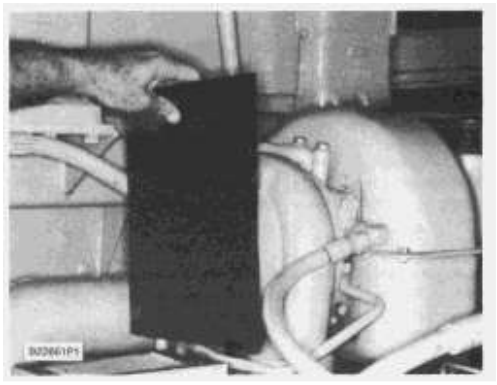
control).

a. Remove the air cleaner so that turbocharger air inlet (7) is open as shown.



Turbocharger With Open Air Inlet
(7) Air inlet.

b. If a pump has been installed wrong and the engine does not run in a normal way, put a steel plate over the air inlet opening as shown to stop the engine.



Stopping The Engine

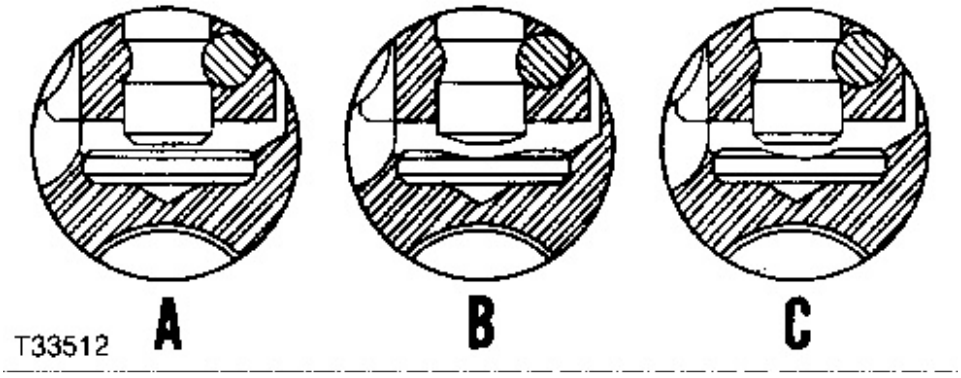
Checking The Plunger And Lifter Washer On An Injection Pump

Check timing dimension for the fuel injection pumps. Make an adjustment if necessary, with the pump housing off the engine. When an adjustment to the timing dimension is done correctly, fuel injection in the cylinder will be at the correct time. If the timing dimension is too small, fuel injection will be early. If the timing dimension is too large, fuel injection will be late.

An injection pump can have a good fuel flow coming from it but not be a good pump because of slow timing that is caused by wear on the bottom end of the plunger. When making a test on a pump that has been used for a long time, use a micrometer and measure the length of the plunger. If the length of the plunger is shorter than the minimum length (worn) dimension given in the chart, install a new pump.

Fuel Pump Plunger			
Length (New)	69.118 ± 0.038 mm (2.7212 ± .0015 in)	69.118 ± 0.013 mm (2.7212 ± .0005 in)	66.424 ± 0.038 mm (2.6151 ± .0015 in)
Minimum Permissible Length	69.079 mm (2.7196 in)	69.079 mm (2.7196 in)	66.385 mm (2.6136 in)
Used With Fuel Injector Pump Group	9W0101	7W0561	7N1185

Look for wear at the top part of the plunger. Check the operation of the plunger according to the instructions for the Fuel Injection Test Bench.



Wear Between Lifter Washer And Plunger
Fig. A shows the contact surfaces of a new pump plunger and a new lifter washer. In Fig. B the pump plunger and lifter washer have worn a large amount. Fig. C shows how the flat end of a new plunger makes bad contact with a worn lifter washer, causing rapid wear to both parts.

When there is too much wear on the pump plunger, the lifter washer may also be worn and there will not be good contact between the two parts. To stop fast wear on the end of a new plunger, install new lifters in the place of lifters that have washers with wear.

Fuel Injection Lines

Fuel from the fuel injection pumps is sent through the fuel injection lines to the fuel injection nozzle.

Each fuel injection line of an engine has a special design and must be installed in a certain location. When fuel injection lines are removed from an engine, put identification marks or tags on the fuel lines as they are removed, so they can be put in the correct location when they are installed.

The nuts that hold a fuel injection line to an injection nozzle and injection pump must be kept tight. Use a torque wrench and the 2P5494 Crowfoot Wrench to tighten the fuel line nuts to 40 ± 7 N·m (30 ± 5 lb ft).

Fuel Bypass Valve

The fuel bypass valve controls fuel pressure to the fuel injection pump at full speed to a pressure of 230 ± 35 kPa (33 ± 5 psi).

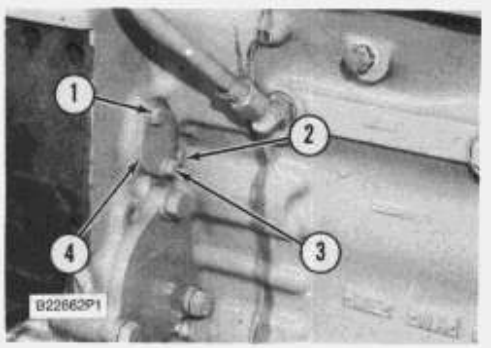
Finding Top Center Compression Position For No. 1 Piston

Tools Needed		
9S9082	Engine Turning Tool	1

NOTE: No. 1 piston at top center (TC) on the compression stroke is the starting point for all timing procedures.

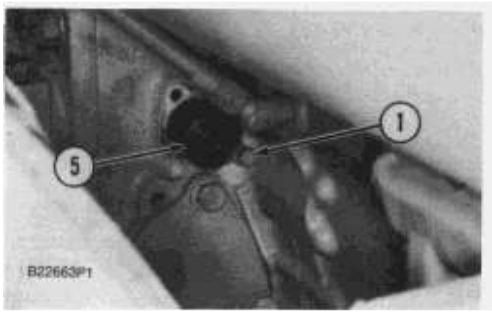
1. Remove timing bolt (1), bolt (3) and cover (4).

2. Remove plug (2).



Locating Top Center
(Right Side Of Engine) (1) Timing bolt (in storage location). (2) Plug. (3) Bolt. (4) Cover.

3. Install 9S9082 Engine Turning Tool (5) in the housing.

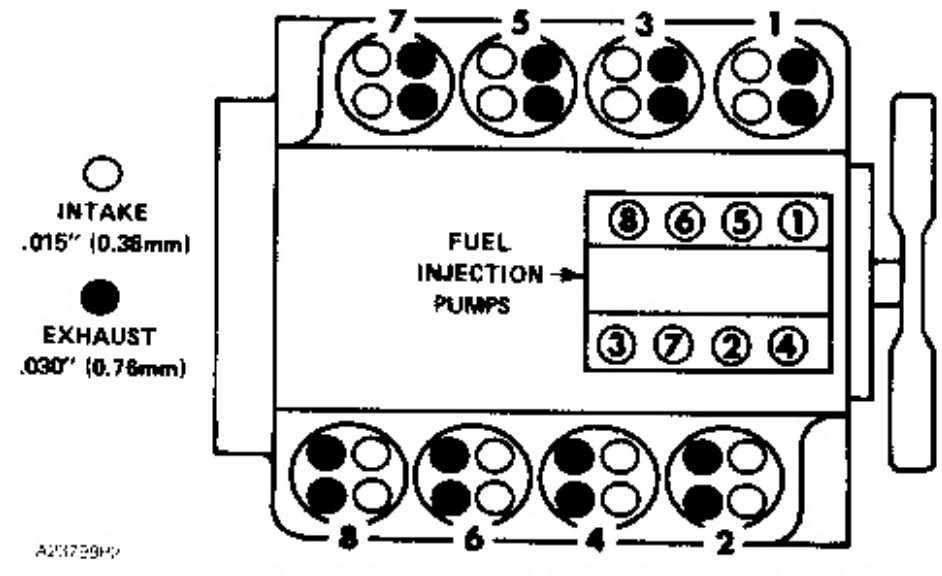


Location For 9S9082 Engine Turning Tool
(1) Timing bolt installed. (5) 9S9082 Engine Turning Tool.

4. Hold timing bolt (1) against the flywheel through the hole from which plug (2) was removed.

5. Use a 1/2 inch drive ratchet and tool (5) to turn the flywheel counterclockwise (as seen from the rear of the engine). Stop when the timing bolt goes into a threaded hole in the flywheel. If the timing bolt can be turned freely in the threaded hole in the flywheel, the No. 1 piston of the engine is on top center.

NOTE: If the hole in the flywheel is turned beyond the hole in the flywheel housing, turn the flywheel back (clockwise) a minimum of 30 degrees. Do Step 5 again. This will prevent timing error caused by play in the timing gears.



Cylinder And Valve Location

6. Remove the left front valve cover. Look at the valves of No. 1 cylinder. The valves will be closed if No. 1 piston is on the compression stroke. You should be able to move the rocker arms up and down with your hand. If No. 1 piston is not on the compression stroke, do the steps that follow.

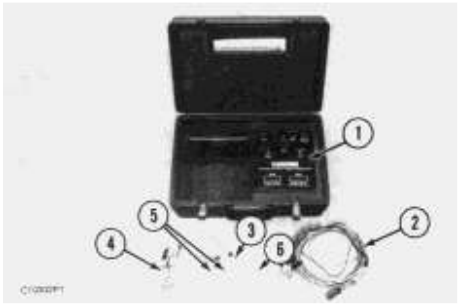
7. Remove the timing bolt from the flywheel.

8. Turn the flywheel 360 degrees counterclockwise and install the timing bolt.

NOTE: If the hole in the flywheel is turned beyond the hole in the flywheel housing, turn the flywheel back (clockwise) a minimum of 30 degrees. Do Step 5 again. This will prevent timing error caused by play in the timing gears.

Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group And 8T5301 Diesel Timing Adapter Group

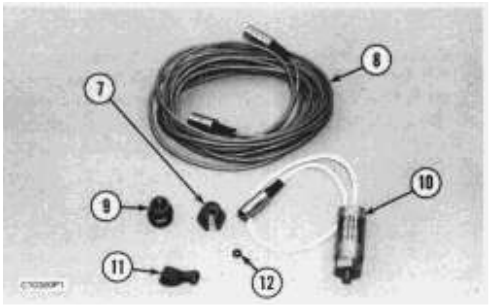
Tools Needed		
8T5300	Timing Indicator Group	1
8T5301	Diesel Timing Adapter Group	1



8T5300 Timing Indicator Group
(1) 8T5250 Engine Timing Indicator. (2) 5P7366 Cable Assembly. (3) 6V2197 Magnetic Transducer. (4) 5P7362 Cable. (5)

6V2199 & 6V3093 Transducer Adapters. (6) 8K4644 Fuse.

The 8T5300 Timing Indicator Group with an 8T5301 Diesel Timing Adapter Group, can be used to measure fuel injection timing for the engine.



8T5301 Diesel Timing Adapter Group
(7) 5P7437 Adapter. (8) 6V2198 Cable. (9) 5P7436 Adapter. (10) 6V7910 Transducer. (11) 5P7435 Adapter. (12) 6V3016 Washer.

When checking the dynamic timing on an engine that has a mechanical advance, Caterpillar recommends that service, personnel calculate and plot the dynamic timing specifications first on a worksheet like Form No. SEHS8140. See Special Instruction, Form No. SEHS8580 for information required to calculate the timing curve. For the correct timing specifications to use, see the Engine Information Plate for the performance specification number and make reference to the Fuel Setting And Related Information Fiche.

NOTE: For more information on acceptable tolerances for dynamic fuel injection timing, see Service Magazine dated 4-1-85 and 10-25-85.

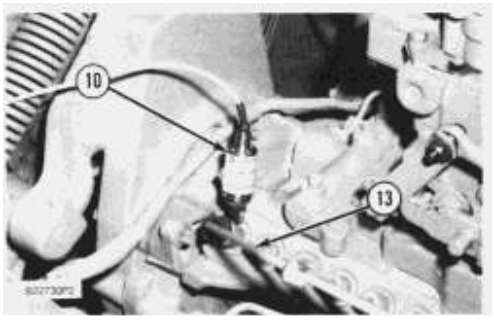
After the timing values are calculated and plotted, the dynamic timing should be checked with the 8T5300 Engine Timing Indicator Group. To do this, service personnel must operate the engine from 1000 rpm (base rpm) to high to high idle and from high idle to 1000 rpm (base rpm). Unstable readings are often obtained below 1000 rpm. He must record the dynamic timing at each 100 rpm and at the specified speeds during both acceleration and deceleration. Then he should plot the results on the worksheet.

Inspection of the plotted values will show if the fuel injection timing is within specification and if it is advancing correctly.

1. Make reference to Special Instructions, Form No. SEHS8580 for complete instructions and calibration of the 8T5300 Timing Indicator Group.

WARNING

The engine must be stopped before the timing indicator group is installed. A high pressure fuel line must be disconnected and a probe must be installed in the flywheel housing.



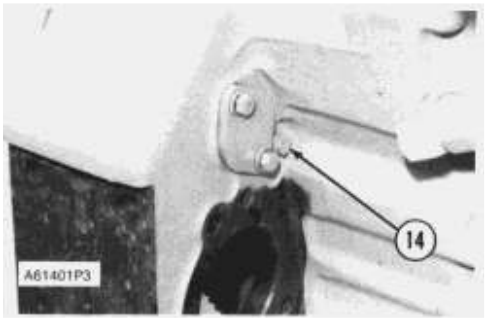
Transducer In Position
(10) Injection transducer. (13) Fuel injection line for No. 1 cylinder.

2. Disconnect fuel injection line (13) for No. 1 cylinder. Slide the nut up and out of the way. Put 5P7436 Adapter (9) in its place and turn the adapter onto the fuel pump bonnet until the top of the bonnet threads are approximately even with the bottom of the "window" in 5P7436 Adapter (9).

3. Put 5P7435 Tee Adapter (11) on injection transducer (10) and put the end of 5P7435 Tee Adapter (11) in the "window" of 5P7436 Adapter (9).

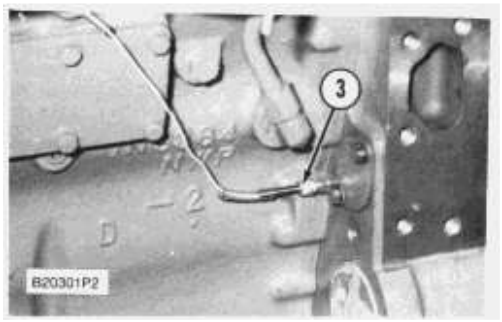
4. Move the end of fuel line (13) down on top of 5P7435 Tee Adapter (11). Hold fuel line (13) in place with 5P7437 Adapter (7) and tighten to a torque of no more than 40 N·m (30 lb ft).

5. Remove plug (14) from timing hole in flywheel housing. Install transducer adapter (5) into the timing hole and tighten just a small amount more than finger tight.



Timing Hole Location
(14) Plug.

6. Push magnetic transducer (3) into adapter (5) until it makes contact with the flywheel. Pull it back out 1.5 mm (.06 in) and finger tighten the knurled locknut.



Transducer In Position
(3) Magnetic transducer.

7. Connect the cables from the transducer to engine timing indicator (1). Calibrate and make

adjustments. For calibration procedure, refer to Special Instruction Form No. SEHS8580.

8. Start the engine and let it reach operating temperature. Then run the engine at approximately one half throttle for eight to ten minutes before measuring timing.

9. Run the engine at the speeds required to check low idle, automatic timing advance and high idle. Record the engine timing indicator readings. If the engine timing is not correct, make reference to Fuel System Adjustments: On Engine, Fuel Injection Pump Timing (Timing Pin Method) for static adjustment of the fuel injection pump drive.

10. If the timing advance is still not correct, or if the operation of the advance is not smooth, make a repair or replacement of the automatic advance unit. There is no adjustment to the unit.

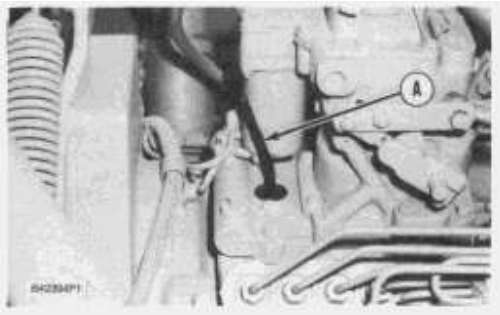
Fuel System Adjustments: On Engine

Camshaft Timing For The Fuel Injection Pump

Tools Needed		
6V6019	Timing Pin	1

1. Put No. 1 piston at top center (TC) on compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston.

NOTE: A 1P3566 9/16 Hex Bit cut to a length of 25 mm (1.0 in) can be used to remove the plug from the front end of the injection pump housing.



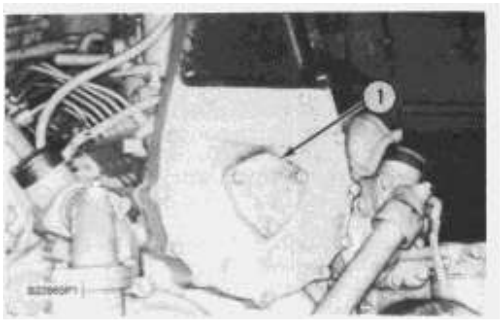
Timing Pin Installed
(A) 6V6019 Timing Pin.

2. Remove the plug at the front end of the fuel injection pump housing.

3. Install 6V6019 Timing Pin (A) [end with taper] through the hole in the injection pump housing.

4. If timing is correct, the timing pin will go into the notch in the camshaft and the timing bolt will turn into the threaded hole in the flywheel. If timing is NOT correct, the timing must be changed.

NOTE: If timing is correct, Be Sure To Remove Timing Pin And Timing Bolt.

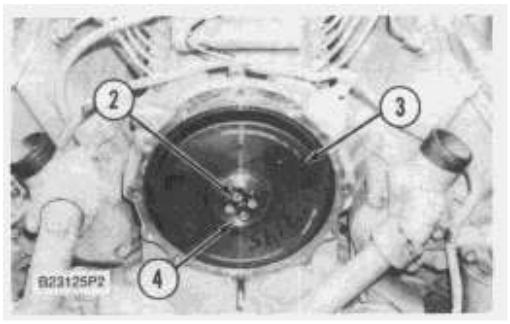


Access Cover To Automatic Timing Advance Unit
(1) Cover.

If timing was NOT correct, remove timing pin and use the procedure that follows to change the timing.

a. Remove access cover (1) to the four bolts of the automatic timing advance unit.

b. Be sure the timing pin is removed before you loosen the bolts. Loosen the four bolts (2) which hold automatic timing advance unit (3) on the fuel pump camshaft.



Automatic Timing Advance Unit
(2) Bolts. (3) Automatic timing advance unit. (4) Retainer.

c. Tighten the bolts (2) with fingers until there is a small amount of friction (slight drag) between the retainer (4) and the timing advance unit (3). This friction will hold the unit against the timing gears. This prevents play (backlash) when gears are turned to the correct position.

d. Remove the timing bolt. Turn the flywheel until the timing pin will go into the groove in the injection pump camshaft.

e. With the timing pin installed, turn the flywheel clockwise (opposite the direction of engine rotation) a minimum of 30 degrees. The reason for this step is to be sure the play is removed from the timing gears when the engine is put on top center (TC).

f. Turn the flywheel in the direction of engine rotation until the No.1 piston of the engine is on top center compression stroke. Then turn the timing bolt into the threaded hole in the flywheel.

g. Tighten bolts (2) to 25 N·m (20 lb ft). Then remove the timing pin from the injection pump housing.

h. Tighten bolts (2) to 135 ± 7 N·m (100 ± 5 lb ft). Then remove the timing bolt from the flywheel.

5. Turn the crankshaft two complete revolutions and check the timing again to see that timing pin will go into notch in camshaft with bolt in flywheel.

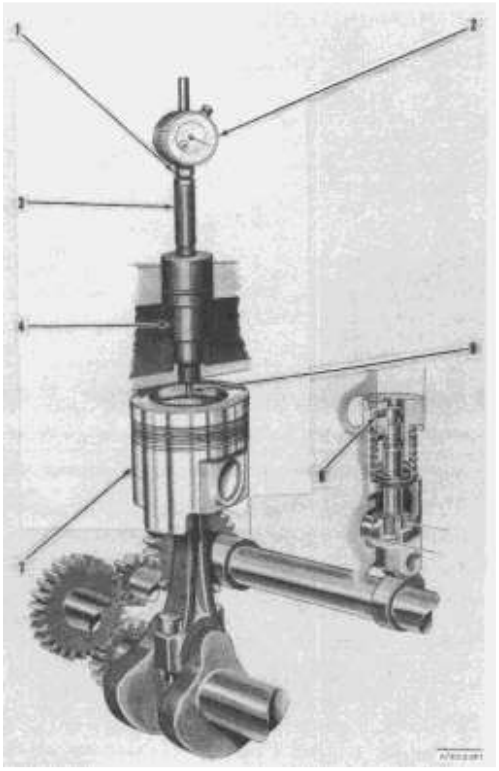
6. If timing is not correct, do the procedure of Steps b thru h again.

NOTE: If timing is correct, Be sure To Remove Timing Pin And Timing Bolt.

Flow Checking Method

NOTE: This procedure cannot be used on later engines with 7000 Series Fuel Injection Nozzles.

Tools Needed		
1P0540	Flow Checking Tool Group	1
6V2023	Adapter Group	1
8T5246	Engine Timing Adapter Group	1
8T5340	Adapter	1
6V3075	Dial Indicator	1
3P1565	Collet or	1
5P4814	Collet	1
5P2393	Contact Point	1
5P7261	Contact Point	1
3S3264	Rod	1
6V6019	Timing Pin	1



Measuring Piston Travel
(1) 3P1565 Collet. (2) 6V3075 or 9S215 Dial Indicator and Contact Point. (3) 8T5340 Adapter. (4) Injection nozzle adapter. (5) 3S3264 Rod. (6) Inlet port. (7) Piston.

See Special Instruction Form No. SMHS7083 for complete instructions for the fuel flow method of

engine timing (injection sequence).

The timing dimension should be checked and changed if necessary, to correct any movement in the relation of the fuel injection pump camshaft to the automatic timing advance unit (drive gear) or to correct for worn timing gears.

To find the travel (movement) of piston (7), from the point that injection pump inlet port (6) closes (point fuel injection begins) to top center compression position, use the procedure that follows:

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston.

Timing Pin Installed
(A) 6V6019 Timing Pin.

2. Remove the plug at the front end of the fuel injection pump housing. On earlier engines, the fuel ratio control (if so equipped) must be removed.

3. Install 6V6019 Timing Pin (A) [end with taper] through the hole in the injection pump housing. The timing pin must fit into the notch in the fuel pump camshaft.

NOTE: If No. 1 piston is at top center of compression stroke, and 6V6019 Timing Pin (A) does not fit in the notch in the fuel pump camshaft, make reference to Fuel System Adjustments: On Engine, Fuel Injection Pump Timing (Timing Pin Method).

4. Remove the timing bolt from the flywheel and the timing pin from the fuel injection pump housing.

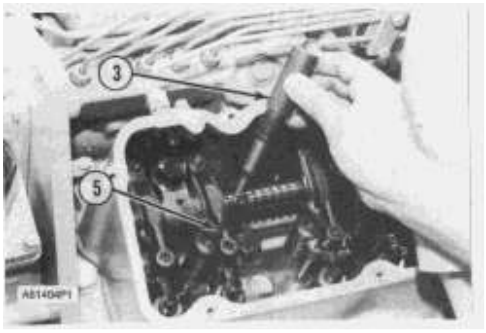
5. Remove the fuel nozzle from the injection nozzle adapter for No. 1 cylinder.

6. Put a small amount of clean oil on 3S3264 Rod (5) and put the rod into adapter (3).

7. Put 8T5340 Adapter (3) in injection nozzle adapter (4) and tighten the adapter finger tight.

NOTICE

Do not use a wrench to tighten the adapter. There will be damage to the nozzle seat if the adapter is too tight.



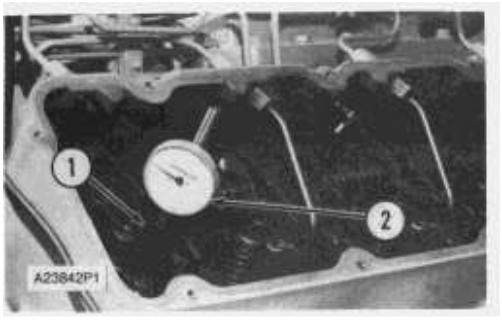
Installing Adapter
(Typical Example) (3) 8T5340 Adapter (5) 3S3264 Rod, 180.9 mm (7.12 in) long.

8. Put the 5P7261 Contact Point and 3P1565 Collet (1) on 6V3075 Dial Indicator (2).

9. Put the assembled indicator into adapter (3). Position the dial indicator (up or down) until the pointers indicate zero and tighten collet (1).

NOTICE

Do not tighten collet too much or damage to the dial indicator can result.



Dial Indicator Installed
(1) 3P1565 Collet. (2) 6V3075 or 9S215 Dial Indicator.

10. Turn the crankshaft a minimum of 30 degrees in the opposite direction of normal rotation.

11. Turn the crankshaft in the direction of normal rotation until the dial indicator gives an indication of maximum piston travel. Loosen collet (1) and adjust the dial indicator until it reads + 7.62 mm (+ .300 in) (black numbers) and tighten collet (1). Zero the outer bezel of the dial indicator.

12. Make sure the No. 1 piston is at the Top Center Position as follows:

a. Slowly rotate the crankshaft in the same direction (normal rotation) until the dial indicator moves past + 7.1 mm (+ .280 in). Now rotate the crankshaft in the opposite direction, moving the piston up, to + 7.1 mm (+ .280 in). Temporarily mark an accessible rotating member (flywheel, vibration damper, or crankshaft pulley) in relation to a stationary pointer or mark.

NOTICE

Do not use a hammer or punch to mark the vibration damper (or any other marking method that could cause damage to the vibration

damper).

b. Continue to rotate the crankshaft in the direction that is opposite of normal rotation, past the maximum reading and past +7.1 mm (+.280 in). Now rotate the crankshaft in the normal direction of rotation, moving the piston up to +7.1 mm (+.280 in). Make a second temporary mark on the desired rotating member.

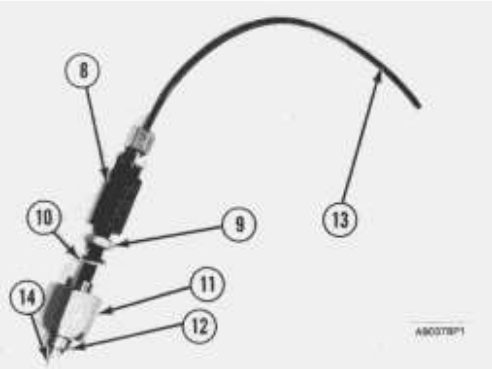
c. Top Center Position is the middle point between the two temporary marks found in Steps a and b above. Turn the crankshaft to this middle point and make a mark to indicate Top Center Position.

13. Disconnect the fuel line and install 6V2023 Adapter Group on No. 1 injection pump with the procedure that follows:

NOTE: Pin (14) is for use only on direct injection engines that have reverse flow check valves. Do not use pin (14) when flow checking an engine that does not have reverse flow check valves.

a. Loosen adapter (12) and turn fitting (8) so that pin (14) is extended to a maximum of 5 mm (.2 in) from the end of adapter (12).

b. Remove tube (13). Put the adapter group in position on No. 1 injection pump. Tighten nut (11) to 40 N·m (30 lb ft) maximum.



6V2023 Adapter Group
(8) Fitting. (9) Nut. (10) Washer. (11) Nut. (12) Adapter. (13) Tube. (14) Pin.

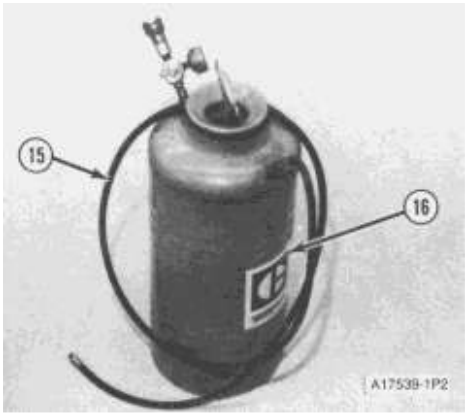
NOTICE

The 6V2018 Pin must not extend more than 5 mm (.2 in) from the end of the 6V2020 Adapter. If the pin is extended too far before installation of the adapter group on to the pump, the reverse flow check valve will be pushed into contact with, and be broken by the pump plunger. The broken parts will then cause the plunger to seize.

c. Turn fitting (8) down until pin (14) makes contact with the reverse flow check valve.

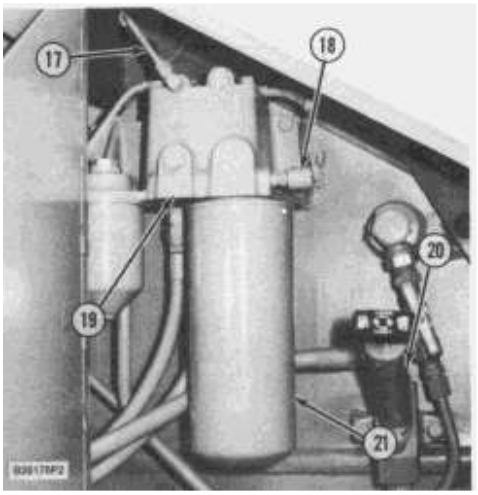
d. Turn the fitting an additional 1/4 turn.

e. Push washer (10) against adapter (12). Tighten nut (9) finger tight. Install tube (13) on the adapter group.



1P540 Flow Checking Tool Group
(15) 5J4634 Hose Assembly. (16) Tank assembly.

14. Remove sender (18) from the side of fuel filter base (19). Connect 5J4634 Hose Assembly (15) to filter base (19), with an adapter. Disconnect fuel return line (17) from the cover of the fuel filter base. Install a plug in the cover.



Fuel Filter Base
(17) Fuel return line. (18) Sender. (19) Fuel filter base. (20) Priming pump. 21) Fuel filter.

15. Turn the crankshaft approximately 45 degrees in a clockwise direction (when seen from the flywheel end of the engine).

16. Put 4 liters (1 US gal) of clean fuel in the tank assembly (16). Move the governor lever to full "fuel-on" position. Put 105 kPa (15 psi) of air pressure in the tank by using the hand pump or shop air.

NOTICE

If shop air is used, be sure to make an adjustment to the regulator so there is only 105 kPa (15 psi) air pressure in the tank.

17. Hold a pan under the free end of tube (13) for the fuel that comes out.

18. Turn the crankshaft slowly in direction of normal rotation. Do this until the flow of fuel coming from the end of tube (13) is 6 to 12 drops per minute [point of closing inlet port (6)].

19. Stop rotation of the crankshaft when the flow of fuel is 6 to 12 drops per minute. Take a reading of the measurement on the dial indicator.

20. Subtract 7.62 mm (.300 in) from the dial indicator reading. To check for correct timing of the fuel system, make a comparison of the measurement with the measurements in the Flow Timing Conversion Chart that follows:

21. If the injection pump timing is wrong, several cylinders can be checked. If they show different readings, remove the injection pump housing to check all lifter settings and plunger lengths, and to adjust as needed. See Setting The Injection Pump Timing Dimension: Off Engine, and Checking The Plunger And Lifter Washer Of An Injection Pump.

NOTE: On all cylinders, top center (TC) of each piston will have to be found by use of the dial indicator.

NOTE: The fuel system has a tolerance of ± 1 degrees.

Flow Timing Conversion Chart

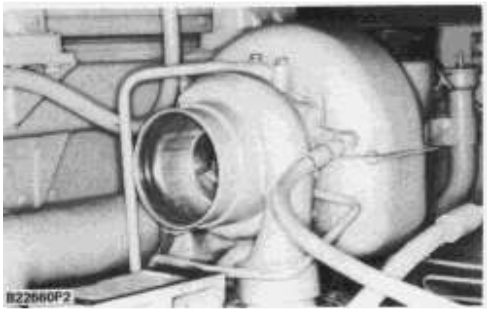
Timing Angle	Indicator Reading	
25 degrees	9.12 mm	.359 in.
26 degrees	9.86 mm	.388 in.
27 degrees	10.59 mm	.417 in.
*28 degrees	11.38 mm	.448 in.
29 degrees	12.17 mm	.479 in.
30 degrees	13.00 mm	.512 in.

* Correct timing angle

WARNING

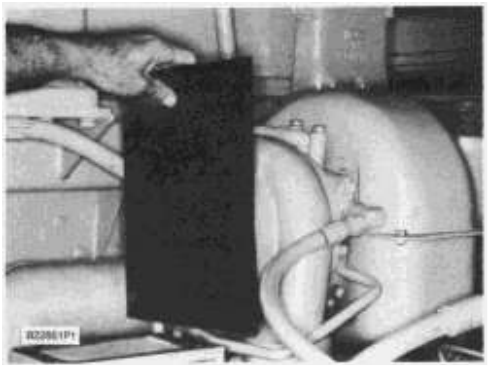
If one or more of the fuel injection pumps have been damaged (or seized in its bore) by incorrect adjustment of the 6V2023 Adapter Group, it is possible for the engine to run out of control when started. After flow checking the engine timing, take the precautions (steps) that follow to stop the engine if it starts to overspeed to prevent engine damage or injury to personnel caused by an engine running out of control.

a. Disconnect the air cleaner from the turbocharger and leave air inlet open as shown.



Turbocharger With Open Air Inlet

b. If a pump plunger has seized in its bore and the engine does not run in a normal way, put a steel plate over the air inlet opening as shown to stop the engine.



Stopping The Engine

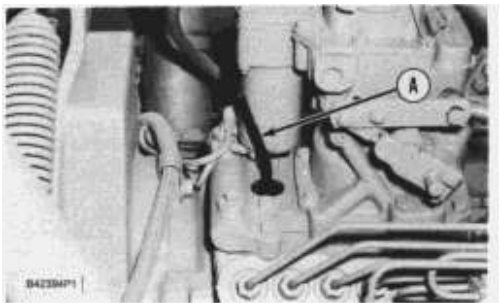
Measuring Fuel Injection Pump Timing Dimension

Tools Needed		
6V7926	Indicator Group	1
8S3158	Indicator	1
3P1565	Collet	1
5P4156	Base	1
5P4163	Contact Point	1
5P4158	Gauge	1
6V6019	Timing Pin	1
8T5287	Wrench	1
8S2244	Extractor	1

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston.

2. Remove the plug at the front end of the fuel injection pump housing.

3. Install 6V6019 Timing Pin (A) [end with taper] through the hole in the injection pump housing. The timing pin must fit into the notch in the fuel pump camshaft.



Timing Pin Installed
(A) 6V6019 Timing Pin.

NOTE: If No. 1 piston is at top center of compression stroke, and the 6V6019 Timing Pin does not fit in the notch in the pump camshaft, make reference to Camshaft Timing For The Fuel Injection Pump.

4. Before any fuel injection pump can be removed, the fuel racks must be put in the center position. Make reference to Removal Of Injection Pump.

5. Remove No. 1 fuel injection pump with 8T5287 Wrench and 8S2244 Extractor. Put 5P4158 Gauge (4) into the bore in the fuel pump housing.

6. Put 3P1565 Collet (2) and 5P4156 Base (3) on 8S3158 Indicator (1). Put 5P4163 Contact Point (5) on the indicator.

7. To adjust (calibrate) the dial indicator for the lifter measurements, use the procedure that follows:

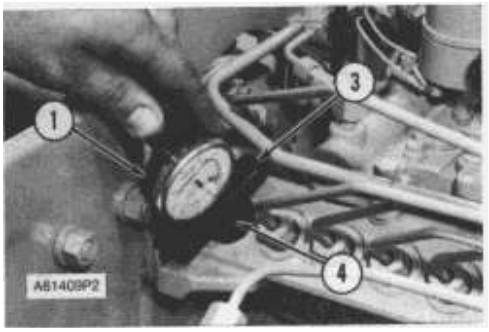
a. Put the 5P4157 Gauge [101.6 mm (4.00 in)] on the 5P4159 Gauge Stand.

b. With contact point in gauge hole, put the dial indicator and base on top of 5P4157 Gauge.

c. Loosen the screw that locks the dial face. Move the dial face until large pointer is on zero and tighten the screw.

d. Make a record of the position of the small pointer. The dial indicator is now adjusted (calibrated).

NOTE: When measurement of the pump timing dimension is made, find the difference between the adjustment reading and the present reading on the dial face. A dimension of 101.6 mm (4.00 in) must be added to the difference in indicator readings for the correct measurement.



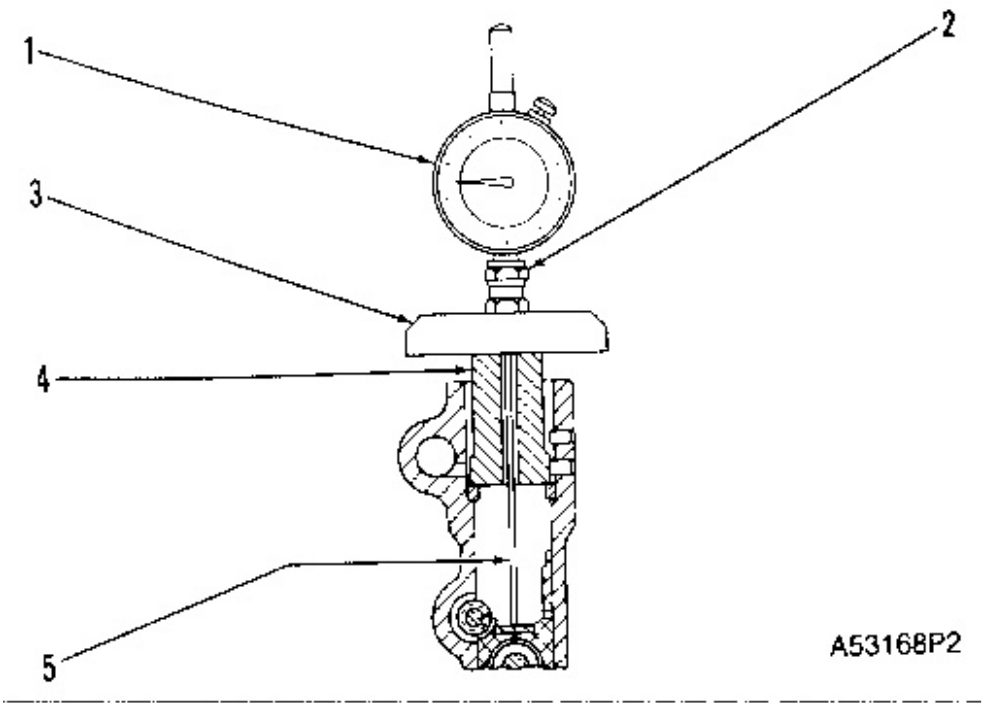
Checking Timing Dimension
(Typical Illustration) (1) Dial indicator. (3) Base. (4) Gauge.

8. Install the indicator assembly through 5P4158 Gauge (4).

9. The correct timing dimension using dial indicator (1) is:

Timing dimension (on engine) ... 106.017 ± 0.051 mm (4.1739 ± .0020 in)

NOTE: If the timing of the fuel system is different than the correct timing dimension given in the chart, and the camshaft timing for the fuel injection pump is correct, remove the injection pump housing to check all lifter settings and plunger lengths, and to adjust as needed. Make reference to Fuel System Adjustments: Off Engine, and Checking The Plunger And Lifter Washer Of An Injection Pump.

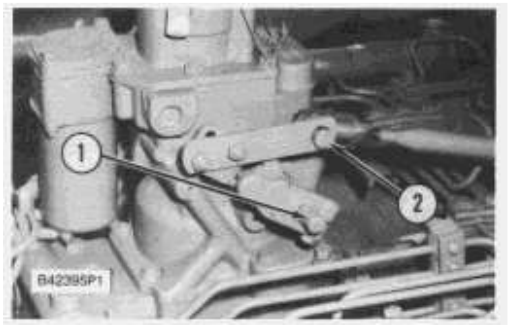


Checking Timing Dimension
(1) 8S3158 Dial Indicator. (2) 3P1565 Collet. (3) 5P4156 Base. (4) 5P4158 Gauge - 50.8 mm (2.00 in) long. (5) 5P4163 Contact Point, 120.7 mm (4.75 mm) long.

10. If the timing dimension is correct, install the No. 1 fuel injection pump into the bore in the pump housing. Make reference to Installation Of Injection Pump.

Fuel Rack Setting

Tools Needed		
6V9128	Rack Position Tool Group	1
8T0500	Circuit Tester	1
6V3075	Dial Indicator	1
9S8883	Contact Point	1
3P1565	Collet	1
6V6019	Timing Pin	1
5P7335	Rack Adjusting Tool	1



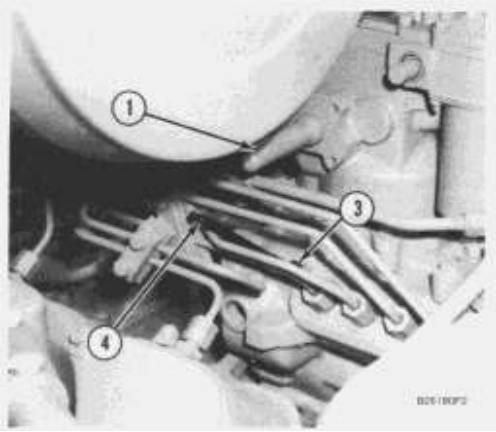
Governor And Injection Pump Housing

(1) Governor control shaft. (2) Control linkage.

1. Disconnect governor control linkage (2) so governor control shaft (1) can move freely through its full travel.

2. Move governor control shaft (1) to the Shutoff Position.

3. Remove plug from hole (3). Put 6V6019 Timing Pin (4) in hole (3) with the flat end down.



Put Rack At Zero Position
(1) Governor control shaft. (3) Hole. (4) 6V6019 Timing Pin.

4. Turn governor control shaft (1) toward High Idle and push down on timing pin (4) until it engages in the slot (groove) in the rack. The rack is now centered (at zero position).

5. Remove the plug at the rear of the housing.

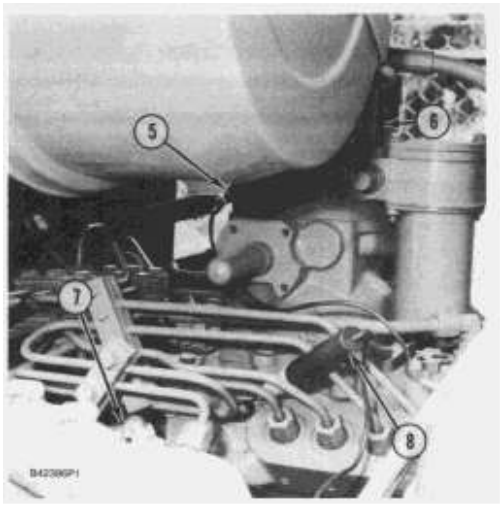
6. Put 3P1565 Collet and 6V3075 Dial Indicator (7) with the 9S8883 Contact Point in the hole at the rear of the housing.

7. Adjust the indicator to "0" (zero). Tighten the nut of the collet to hold the indicator at the zero position.

8. Remove timing pin (4).

9. Connect the clip end of 8T0500 Circuit Tester (8) to brass terminal (5) on governor housing. Put the other end of the tester to a good ground.

10. Turn governor control shaft (1) in the fuel on direction until the light in the tester shows a maximum output. Turn the shaft in the fuel off direction until the test light goes out. Turn the shaft slowly in the fuel on direction until the test light has a minimum light output. In this position, rack stop collar (12) just starts to make contact with the torque spring.



Check Rack Setting
(5) Brass terminal. (6) Fuel ratio control. (7) 6V3075 Dial Indicator. (8) 8T0500 Circuit Tester.

11. Read the fuel rack setting dimension directly from the dial indicator. See the Fuel Setting And Related Information Fiche, or look at the Engine Information Plate installed on the engine, to find the correct measurement for rack setting.

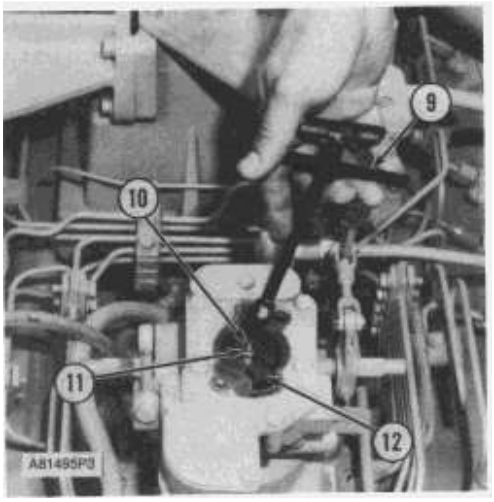
12. If adjustment of the fuel rack setting is needed, remove the fuel ratio control (if so equipped) or cover from top of governor. Use tool (9) to loosen locknut (11) and turn the adjustment screw (10) as needed.

NOTE: To decrease the fuel rack setting, turn the adjustment screw clockwise.

13. Tighten locknut (11). Check the rack setting according to Steps 11 and 12.

14. When the fuel rack setting is correct, use tool (9) to hold screw (10) and tighten locknut (11) to 12 ± 4 N·m (9 ± 3 lb ft).

15. Install the fuel control on the governor. Connect the governor control linkage. Make reference to Fuel Ratio Control Adjustment.



Adjustment To The Rack Setting (Typical Example)
(9) 5P7335 Rack Adjusting Tool. (10) Adjustment screw. (11) Locknut. (12) Stop collar.

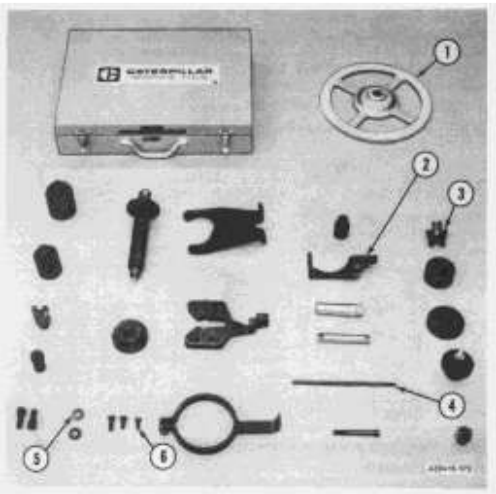
Fuel System Adjustments: Off Engine

Setting Fuel Injection Pump Dimension

Tools Needed		
6V4180	Off Engine Lifter Setting Tool Group	1
6V6019	Timing Pin	1
5P1768	Pointer	1
5P3601	Lifter Setting Adapter	1
1P7410	Plate	1
2S6160	Washer	1
0S1617	Bolt, 19.1 mm (.75 in) long	1
2A0762	Indicator Group, 15.7 mm (.62 in) long	1
8S3158	Indicator	1
3P1565	Collet	1
5P4156	Base	1
5P4163	Contact Point, 120.7 mm (4.75 in) long	1
5P4158	Gauge, 50.8 mm (2.00 in) long	1
8T5287	Wrench	1
8S2244	Extractor	1

The off engine setting makes an adjustment for wear of components in the injection pump housing. Adjustment of the fuel camshaft timing gives compensation for wear in the timing gears and on the camshaft of the injection pumps.

1. Use the 8T5287 Wrench and 8S2244 Extractor to remove the injection pumps.



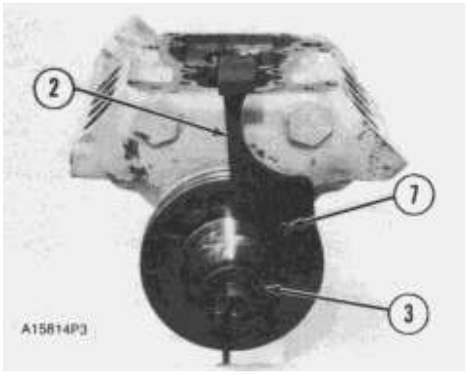
5P6600 Off Engine Lifter Setting Tool Group
(1) 1P7410 Timing Plate. (2) 5P1768 Pointer Assembly. (3) 5P3601 Adapter. (4) 5P9697 Timing Pin. (5) 2S6160 Washer. (6) 0S1617 Bolt.

2. Fasten 5P1768 Pointer Assembly (2) to the pump housing with 2A0762 Bolt (7).

3. Install 5P3601 Adapter (3) on the drive end of the injection pump camshaft.

4. Install 6V6019 Timing Pin (4) (end with taper) through the timing hole in the pump housing and into the notch in the camshaft.

5. Put 1P7410 Timing Plate (1) on 5P3601 Adapter (3) and install 2S6160 Washer (5) and 0S1617 Bolt (6). Do not tighten bolt.



Installation Of The 5P1768 Pointer
(2) 5P1768 Pointer. (3) 5P3601 Adapter. (7) 2A0762 Bolt.

6. Turn 1P7410 Timing Plate (1) until the starting point degree mark on the 1P7410 Timing Plate (1) is in alignment with the pointer:

Starting point degree mark ... 14 degrees

7. Tighten bolt (6) to a maximum of 25 N·m (20 lb ft).

NOTE: Be sure 1P7410 Timing Plate does not move from the starting point degree mark while the bolt is tightened.

8. Remove timing pin (4).

9. Make reference to the lifter setting chart for the timing plate degrees for the lifter being checked. To use the timing plate, turn it counterclockwise until the degree setting for the lifter being checked is in alignment with the pointer.

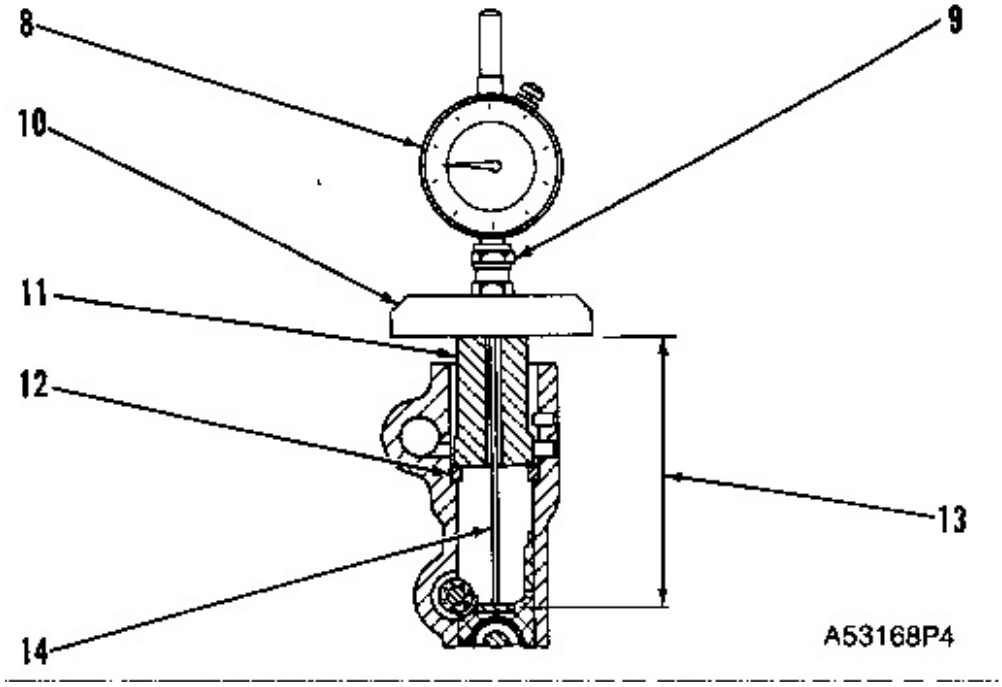
10. To adjust (calibrate) the dial indicator for the lifter measurements, use the procedure that follows:

a. Put the 5P4157 Gauge [101.6 mm (4.00 in)] on the 5P4159 Gauge Stand.

b. With contact point in gauge hole, put the dial indicator and base on top of 5P4157 Gauge.

c. Loosen the screw that locks the dial face. Move the dial face until the large pointer is on zero and tighten the screw.

d. Make a record of the position of the small pointer. The dial indicator is now adjusted (calibrated).



Measuring Timing Dimension
(8) 8S3158 Indicator. (9) 3P1565 Collet. (10) 5P4156 Base. (11) 5P4158 Gauge - 50.8 mm (2.00 in). (12) Spacer. (13) Timing dimension. (14) 5P4163 Contact Point - 120.7 mm (4.75 in) long.

NOTE: When measurement of the pump timing dimension is made, find the difference between the adjustment reading and the present reading on the dial face. A dimension of 101.6 mm (4.00 in) must be added to the difference in indicator readings for the correct measurement.

11. The off engine timing dimension for adjustment of the lifter, is shown in Lifter Setting Chart.

Lifter Setting Chart (Off Engine)		
Timing Plate Starting Point (Initial setting with timing pin in slot) DI.....14 degrees		
Turn Timing Plate Counterclockwise to (degrees)	Lifter Number (Shown above each pump hole)	Timing Dimension for all Lifters
0	1	
45	8	
90	4	
135	3	
180	6	110.335 ± 0.051 mm
225	5	(4.3439 ± 0.0020 in)
270	7	
315	2	

12. The spacer (12) of each injection pump must be changed to change the timing dimension of that injection pump. Make reference to the spacer chart for spacer thickness.

13. Make another check of all timing dimensions after all adjustments have been made.

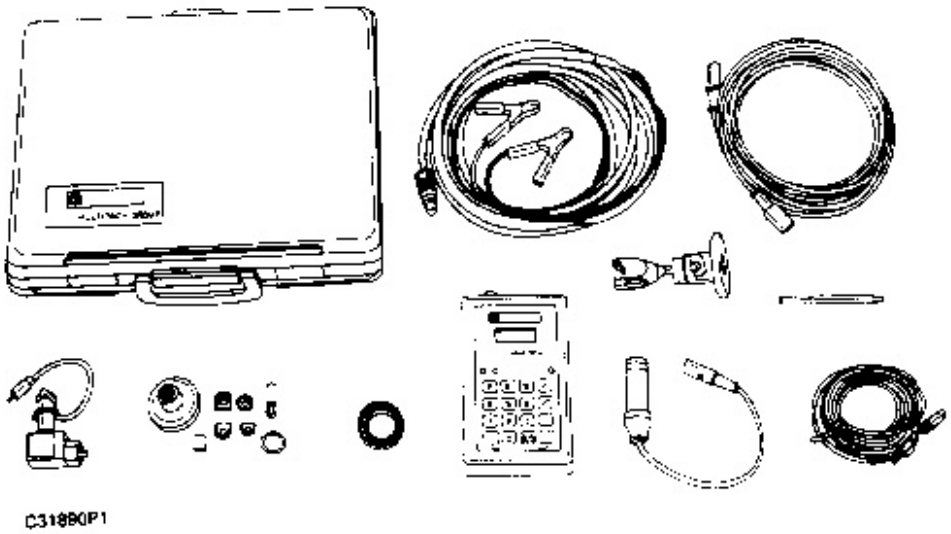
14. Make reference to Installation Of Injection Pump to install pumps in housing and to check for full travel of fuel racks.

15. After the fuel injection pump housing is again installed on the engine, make reference to Camshaft Timing For The Fuel Injection Pump.

Spacer Chart	
Spacer Part No.	**Spacer Thickness**
9N6496	4.12 mm (.162 in)
9N6495	4.22 mm (.166 in)
5M2697	4.32 mm (.170 in)
2M4208	4.42 mm (.174 in)
2M4209	4.52 mm (.178 in)
2M4210	4.62 mm (.182 in)
2M4211	4.72 mm (.186 in)
2M4212	4.83 mm (.190 in)
5M2691	4.93 mm (.194 in)
5S7189	5.03 mm (.198 in)

Engine Speed Measurement

Tools Needed		
6V3121	Multitach Group	1



6V3121 Multitach Group

The 6V3121 Multitach Group can measure engine speed from a magnetic pickup on the flywheel housing. It also has the ability to measure engine speed from visual engine parts in rotation.

Special Instruction, Form No. SEHS7807 is with the 6V3121 Multitach Group and gives instructions for the test procedure.

Governor Adjustments

NOTICE

A mechanic with training in governor adjustments is the only one to make the adjustment to the set point rpm.

Engine rpm must be checked with an accurate tachometer. Make reference to Engine Speed Measurement.

Low Idle Adjustment

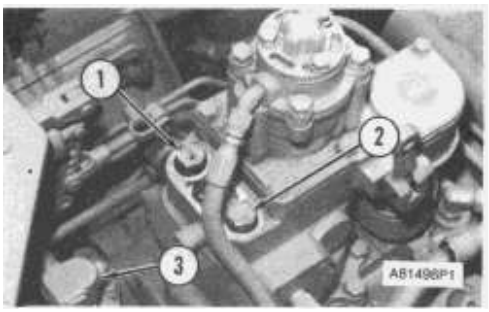
NOTE: The correct Low Idle rpm is given in the Fuel Setting And Related Information Fiche.

WARNING

To help prevent an accident caused by parts in rotation, work carefully around an engine that has been started.

Start the engine and run until the temperature of normal operation is reached. Check low idle rpm with no load on the engine. If an adjustment is necessary, use the procedure that follows:

1. Remove the sealed cover over the High and Low Idle adjustment screws.



Idle Adjustment
(1) Adjustment screw for high idle. (2) Adjustment screw for low idle. (3) Tachometer drive.

2. To adjust the Low Idle rpm, move the governor control to Low Idle position and turn screw (2). Increase the engine speed and then return control back to Low Idle position to check the setting again.

3. When governor adjustment is correct, install the cover over the adjustment screws.

When the cover is installed on the governor, the idle adjustment screws fit into holes in the cover. The

shape of the holes will not let the idle adjustment screws turn after the idle adjustment is done and the cover is installed.

4. Now install a new wire and seal to the cover bolt.

Checking Set Point (Balance Point)

The engine set point is an adjusted specification and is important to the correct operation of the engine. High idle rpm is NOT an adjusted specification. Set point (formerly balance point) is full load rpm plus an additional 20 rpm. Set point is the rpm at which the fuel setting adjustment screw and stop or first torque spring just start to make contact. At this rpm, the fuel setting adjustment screw and stop or first torque spring still have movement between them. When additional load is put on the engine, the fuel setting adjustment screw and stop or first torque spring will become stable against each other. Set point is controlled by the fuel setting and the high idle adjustment screw.

There is a new and more accurate method for checking the "set point," formerly called the balance point, of the engine. If the tools for the new method are not available, there is an alternate method for checking the "set point."

Tools Needed		
6V4060	Engine Set Point Indicator Group	1

The 6V4060 Engine Set Point Indicator Group with the 6V2100 Multitach can be used to check the set point. Special Instruction Form No. SEHS7931 gives instructions for installation and use of this tool group.

6V4060 Engine Set Point Indicator Group

Alternate Method

Tools Needed		
8Y0500	Circuit Tester	1
6V3121	Multitach Group	1

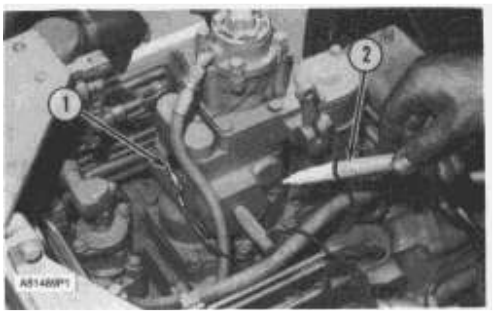
NOTE: Do not use the vehicle tachometer unless its accuracy is known to be within ± 1 rpm.

If the set point is correct and the high idle speed is within specifications, the fuel system operation of the engine is correct. The set point for the engine is:

A. At 20 rpm greater than full load speed.
B. The rpm where the fuel setting adjustment screw stop or first torque spring just make contact.

Use the procedure that follows to check the set point. Make reference to Techniques For Loading Engines in Special Instruction Form No. SEHS7050.

1. Connect a tachometer which has good accuracy to the tachometer drive.



Circuit Tester Installed
(1) Brass terminal screw. (2) 8T0500 Circuit Tester.

2. Connect the clip end of the 8T0500 Circuit Tester to the brass terminal screw (1) on the governor housing. Connect the other end of the tester to a place on the fuel system which is a good ground connection.

WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.

3. Start the engine.

4. With the engine at normal conditions for operation, run the engine at high idle.

5. Make a record of the speed of the engine at high idle.

6. Add load on the engine slowly until the circuit tester light just comes on (minimum light output). This is the set point.

7. Make a record of the speed (rpm) at the set point.

8. Repeat Step 6 several times to make sure that the reading is correct.

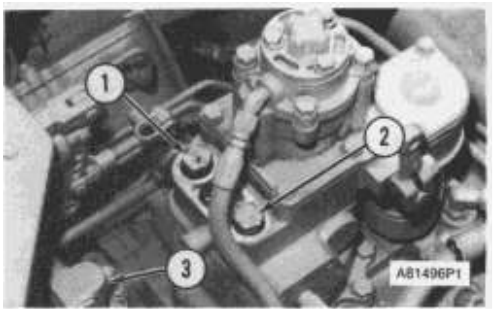
9. Stop the engine. Make a comparison of the records from Steps 5 and 7 with Full Load Speed from the Engine Information Plate. If the Engine Information Plate is not available, see the Fuel Setting And Related Information Fiche. The tolerance for the set point is ± 10 rpm. The tolerance for the high idle rpm is ± 50 rpm in chassis and ± 30 rpm on a bare engine. If the readings from Steps 5 and 7 are within the tolerance, no adjustment is needed.

NOTE: Later model engines have the actual Dyno High Idle stamped on the Engine Information Plate. It is possible, in some applications that the high idle rpm will be less than the actual lower limit. This can be caused by high parasitic loads such as hydraulic pumps, compressors, etc.

Adjusting Set Point (Balance Point)

1. If the set point and the high idle rpm are within tolerance, no adjustment is to be made.

2. If the set point rpm is not correct, remove the sealed cover over the High and Low Idle adjustment screws.



Set Point Adjustment
(1) Adjustment screw for high idle. (2) Adjustment screw for low idle. (3) Tachometer drive.

3. Turn adjustment screw (1) to adjust the set point to the midpoint of the tolerance.

4. When the set point is correct, check the high idle rpm. The high idle rpm must not be more than the high limit of the tolerance.

If the high idle rpm is more than the high limit of the tolerance, check the governor spring and flyweights. If the high idle rpm is less than the low limit of the tolerance, check for excess parasitic loads and then the governor spring and flyweights.

5. When governor adjustment is correct, install the cover over the adjustment screws.

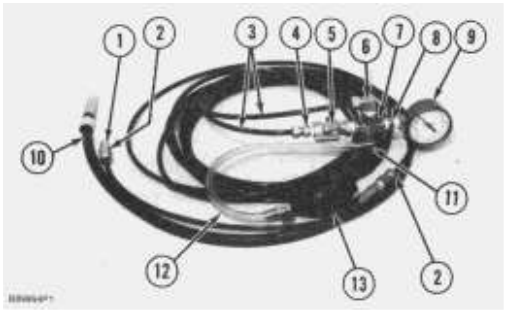
When the cover is installed on the governor, the idle adjustment screws fit into holes in the cover. The shape of the holes will not let the idle adjustment screws turn after the idle adjustment is done and the cover is installed.

6. Now install a new wire and seal to the cover bolt.

Fuel Ratio Control And Governor Check

Tools Needed		
FT1906	Air Test Kit	1
*	Circuit Testing Flashlight or	1
6V4060	Engine Set Point Indicator Group	1
6V9128	Rack Position Tool Group or	1
9S0240	Rack Position Tool Group	1
4N5656	Cover	1

* Commercially available.



FT1906 Air Test Kit
(1) 8L6557 Connector. (2) 5P4405 Connector (two required). (3) 5P6011 Tube [7.3 m (24 ft)]. (4) 5P4476 Connector. (5) 6K5741 Valve. (6) 5P4459 Elbow. (7) 7B192 Cross. (8) 3B6768 Bushing. (9) 9S8138 Gauge. (10) 6N3169 Hose Assembly. (11) 6V6757 Elbow. (12) ** 6.35 mm (.250 in) I.D. Flexible Tubing [1.2 m (4 ft) long]. (13) * Air pressure bulb.

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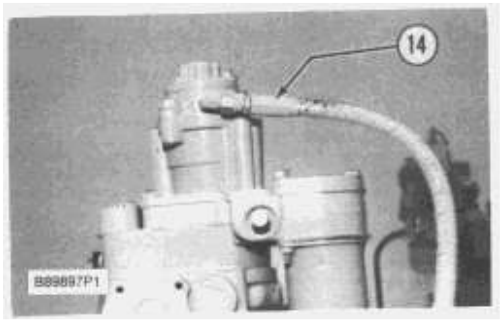
*Baumamometer No. 1890 or equivalent. Available from medical supply store. Bulb must be equipped with valve.

**Available from medical supply store.

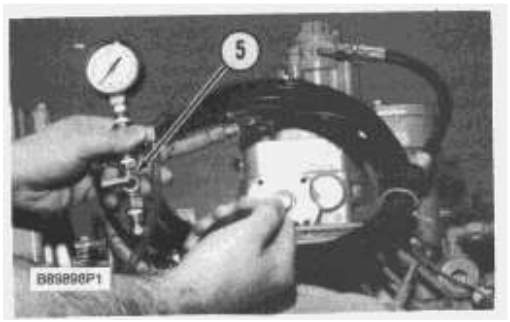
NOTE: The governor seals do not have to be cut or removed for the checking procedures that follow. For more information on the tooling and procedures see Video Tape Form No. SEVV9173 and Special Instruction Form No. SEHS8463 available on microfiche only.



Disconnect Air Line
(14) Air line.

1. Disconnect line (14) from the fuel ratio control and connect FT1906 Air Test Kit between the air inlet manifold and fuel ratio control.

2. Connect the 6V4060 Engine Set Point Indicator Group or a circuit testing flashlight to the continuity contact of the governor.



Check Diaphragm Leakage

(5) Valve.

3. Check fuel ratio control diaphragm leakage.

a. Turn tester valve (5) so manual air pressure can be applied.

b. With the engine shutoff, apply 70 kPa (10 psi) air pressure to the fuel ratio control.

c. Close the valve on air pressure bulb (13) and check the leak down rate. Leakage of 20 kPa (3 psi) in 30 seconds is acceptable.

d. If leakage is more than 20 kPa (3 psi) in 30 seconds, check for external leaks and repair. If necessary, install a new diaphragm in the fuel ratio control and repeat the above steps.

e. When air pressure leakage is acceptable, release all air pressure from the fuel ratio control and proceed to Step 4.

4. Check shutoff linkage and static full fuel rack travel.

a. Turn the ignition switch on, but **do not** start the engine or move the governor control linkage. Observe the shutoff level or shaft. Slowly advance the governor control linkage to the full fuel position. Interference exists if there is any movement of the shutoff lever. If there is interference, check shutoff lever adjustment and linkage alignment.

NOTE: Any contact between the governor control linkage and the shutoff linkage causes power and response problems at high boost when manifold pressure is greater than 381 mm (15 in) Mercury (Hg) or 5.25 kPa (7.5 psi).

b. Move the tooling to the operator's station. Slowly move the governor control linkage to the full fuel position. The lug light or continuity light should come on before 1/2 full fuel position for most fuel system applications.

If the lug light or continuity light does not come on, check linkage travel for correct adjustment. Check shutoff solenoid adjustment. Check the operation of the governor circuit indicator. Look for any restrictions in the governor and linkage operation.

If the light turns on, proceed to Step 5.

5. Check dynamic full fuel rack travel. Zero air pressure to the fuel ratio control.

a. Start the engine. Move the governor control linkage to the full fuel position and release it. Repeat this sequence twice. The continuity light or lug light should come on.

b. If the light does not turn on, the fuel ratio control is activated too early. This can be caused by an incorrect adjustment. Do not adjust the fuel ratio control at this time. Continue to Step 7, because the control has already activated.

c. If the light turns on, proceed to Step 6.

6. Check activation of fuel ratio control.

a. Adjust the governor control linkage to maintain 900 plus or minus 100 rpm.

b. Turn tester valve (5) so that manual air pressure can be supplied and apply 35 kPa (5 psi) for 10 seconds and release all air pressure.

c. Move the governor control linkage to the full fuel position several times. The lug light should not be on. This simulates a low boost pressure that activates the fuel ratio control. If the light comes on apply 35 kPa (5 psi) again and hold this pressure for 10 seconds. With the 2W8449 Orifice installed or when excessive wear of the housing or seals exist additional time may be required to activate the fuel ratio control.

d. If the continuity or lug light turns on after Step c, check the continuity circuit to make sure it is operating correctly. Check the fuel ratio setting and adjust or repair the control as needed.

e. If the continuity or lug light does not turn on, the fuel ratio control is activated and acceptable. Proceed to Step 7.

7. Check full fuel position of the fuel ratio control.

a. Manually apply and hold 25 kPa (4 psi) on the fuel ratio control.

b. Move the governor control linkage to the full fuel position and release it.

c. Increase the air pressure 3.5 kPa (.5 psi) and again move the governor control linkage to the full fuel position and release it.

d. Repeat Step c until the continuity or lug light on the set point indicator turns on. Record this pressure reading. With controls adjusted to a less restrictive setting, full fuel and a continuity light indication can occur before 25 kPa (4 psi).

NOTE: When the light comes on, the fuel ratio control is extended and the fuel rack has moved to the full fuel position. The fuel ratio control has additional travel at higher boost pressures than this reading.

8. Load test to compare engine boost and fuel ratio control movement with the results from Step 7.

a. Turn the tester valve to allow manifold boost readings.

b. With engine speed at 1500 rpm and at low boost, 20 kPa (3 psi) or less, quickly load the engine with full load and full fuel. When the lug or continuity light turns on, record the boost pressure reading. Do this several times to get an accurate reading.

NOTE: An activated light indicates full rack travel. The engine must have a load that requires full fuel. Loads that require less than full fuel will not give consistent readings.

c. The boost reading should be within plus or minus 3.5 kPa (.5 psi) of the reading obtained in Step 7. Repeat this test sequence twice. If a full load test is possible, record the set point rpm, maximum boost, and also horsepower if on a dynamometer.

d. If erratic readings are obtained, either the fuel ratio control, governor or the checking procedure is not operating correctly.

9. Check governor response.

a. Turn the tester valve so that manual air pressure can be applied.

b. Apply 70 kPa (10 psi) or at least 14 kPa (2 psi) air pressure higher that what is recorded from the manual full fuel position check (Step 7). This moves the fuel ratio control away from the rack control position.

c. While under load, move the governor control linkage to its full fuel position. Make a note of how fast

continuity is obtained.

d. If it takes more than 2 seconds to obtain continuity, governor response is not acceptable. Inspect external attachments on the governor for interference or, for excessive shutoff lever contact.

e. Stop the engine.

10. If Steps 3 through 9 show the fuel ratio control and governor operation is acceptable, the checking procedure is complete. If repair of the fuel ratio control or governor is indicated, do the steps that follow for additional troubleshooting.

NOTE: The above checks are used to verify response functions only. The procedures have not checked for correct adjustment of the fuel ratio control and governor fuel settings.

11. Install the fuel setting and measurement tools from the 6V9128 or 9S0240 Rack Position Tool Group. Do not remove the fuel ratio control or shutoff solenoid.

a. Measure the **static full load** setting and compare it to the specification on the Engine Information Plate.

NOTE: If the **static full load** setting is incorrect, continue through Step 15 before any adjustments are made.

12. Measure the **static fuel torque** setting. Move the governor control linkage to its maximum fuel on position and record the full torque reading. At this point, the torque spring is compressed and internal governor clearances are at a minimum.

13. Measure the fuel rack setting with the fuel ratio control activated:

a. Start the engine and run it at 900 rpm.

b. Apply 35 kPa (5 psi) air pressure for 10 seconds to activate the fuel ratio control. Now, release all air pressure on the fuel ratio control.

c. Move the governor control linkage to the full fuel on position and release it. Record the **dynamic fuel ratio control** setting.

14. Check the **dynamic full torque** setting. (Engine running with no load).

a. Apply and hold 70 kPa (10 psi) air pressure to extend the fuel ratio control to a position beyond the full fuel position.

b. Move the governor control linkage to the full fuel position and release it. Record the **dynamic full torque** setting.

c. The **dynamic full torque** setting should be 0.41 to 0.61 mm (.016 to .024 in) more than the **static full torque** setting measured in Step 12. This shows the amount of governor servo piston movement which must be 0.41 to 0.61 mm (.016 to .024 in).

d. If the **dynamic full torque** setting is 0.36 mm (.014 in) or less than the **static full torque** setting measured in Step 12, the fuel rack does not have full travel. This indicates there is interference between parts or there are internal governor problems. Also, the shutoff system can require inspection. Do Step e.

e. With 70 kPa (10 psi) air pressure still on the fuel ratio control, hold the fuel shutoff lever completely

out of the way. Move the governor control linkage to the full fuel position and note the **dynamic full torque** setting. If the setting increases to the range given in Step c, then the shutoff lever linkage needs adjustment or repair. If the setting does not change continue to Step 15.

15. Check governor servo and shutoff circuit.

a. With the engine shutdown, remove the fuel ratio control. Install a 4N5656 Cover. Measure the **static full torque** setting and compare this setting with the setting measured in Step 12. The two settings must be the same or repair of the fuel ratio control is needed.

b. Start the engine. Move the governor control linkage to the full fuel position and release it. Record the **dynamic full torque** setting and compare the setting with the setting measured in Step 14b.

c. If the dynamic movement is the same as Step 14b, the fuel ratio control is working correctly. If there is more than 0.25 mm (.010 in) difference, check for shutoff interference of internal governor linkage problems.

16. Make any fuel setting adjustments necessary.

NOTE: See Fuel Rack Setting for the correct procedure to install the tooling to make the adjustment.

17. If the governor gives slow response, check for restricted rack movement. Also, check for other governor problems. No specific repair procedures are available.

NOTE: Response is the engine's ability to accelerate, under load, to its rated horsepower. Low power is the engine's inability to produce rated horsepower.

Poor response can result from problems with the governor, the fuel ratio control or the shutoff system. Low power can result from problems with the fuel pump, the governor setting, the shutoff system or the other fuel flow components, or with the engine application.

Fuel Ratio Control Adjustment

1. The fuel rack setting must be correct before the adjustment for the fuel ratio control can be checked. Make reference to Fuel Rack Setting.

NOTE: The 9S0215 Dial Indicator for fuel rack setting is used for the adjusment of fuel ratio control.

2. Remove cover (3) from the fuel ratio control.

WARNING

To help prevent an accident caused by parts in rotation, work carefully around an engine that has been started.

3. Start the engine.

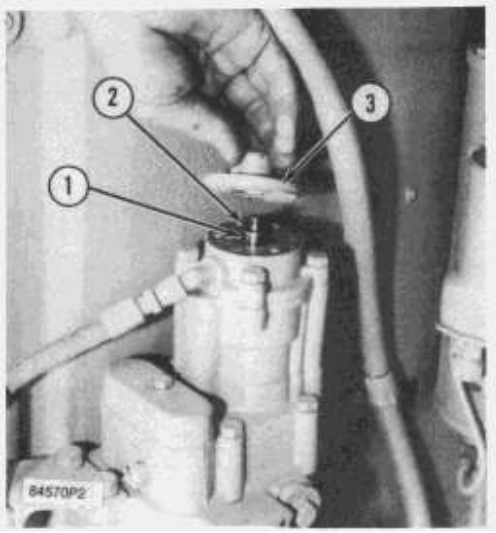
4. Push the end of valve (1) in and hold it in for two or three seconds. This action will manually move the valve into its operating position.

5. Move the governor control lever in the Fuel On direction, then return it to Low Idle. Do this several times to remove the air from the oil in the control. This will make the result of the test more accurate.

6. Rapidly move the governor control lever in the Fuel On direction. Read the maximum measurement on the dial indicator. This is the **dynamic fuel ratio control** setting. See the Fuel Setting And Related Information Fiche for the correct setting.

7. To make an adjustment to the fuel ratio control, turn valve (1) in a clockwise direction to increase the amount of fuel possible (more rack travel) at the limited rack position. Turn the valve counterclockwise to decrease the amount of fuel possible (less rack travel).

8. After an adjustment is made, do Step 6 again. When the adjustment is correct, put cover (3) on the control. Turn the cover as necessary to put it in alignment with the nearest bolt holes. Install the bolts.

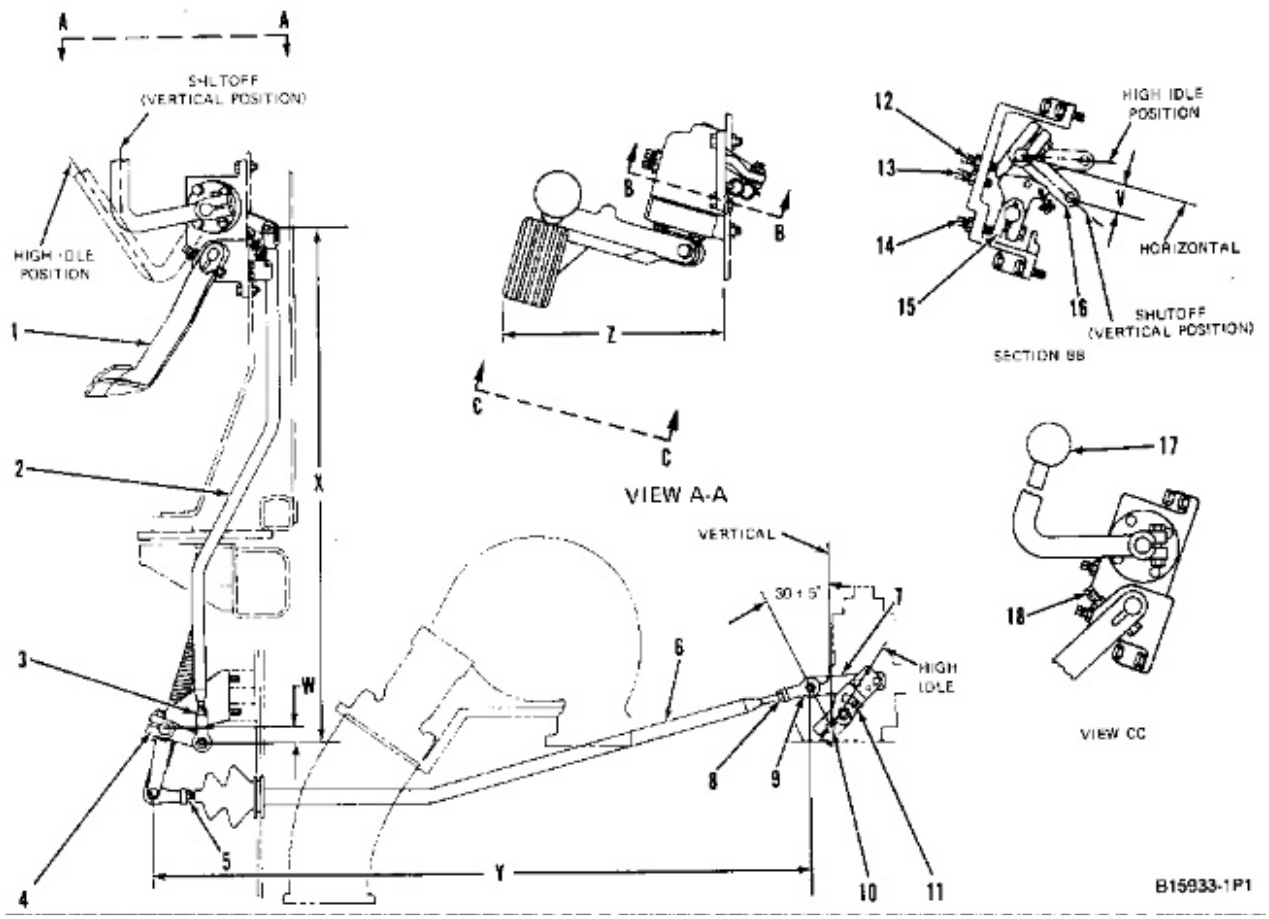


Fuel Ratio Control
(1) Valve. (2) Pin. (3) Cover.

9. Stop the engine. After the oil pressure has gone out of the fuel ratio control, check the fuel rack setting again to make sure full rack travel is available.

Governor Control Adjustments

D8L (Earlier)



Adjusting Governor Control
(1) Decelerator pedal. (2) Rod. (3) Locknut. (4) Lever. (5) Locknut. (6) Rod. (7) Plate. (8) Locknut. (9) Rod end. (10) Governor shaft. (11) Control group. (12) Setscrew. (13) Setscrew. (14) Setscrew. (15) Lever. (16) Lever. (17) Throttle lever. (18) Setscrew. (V) 27.5 ± 1.0 mm (1.08 ± .04 in). (W) 20 ± 1 mm (.79 ± .04 in). (X) 720 ± 2 mm (28.3 ± .08 in). (Y) 956 mm (37.6 in) dimension. (Z) 241 ± 17 mm (9.5 ± .7 in) dimension.

1. Remove rods (2) and (6). Adjust rod (2) to dimension (X) at 720 ± 2 mm (28.3 ± .08 in). Tighten locknut (3) to 12 ± 4 N·m (9 ± 3 lb ft). Adjust rod (6) to approximate dimension (Y) of 956 mm (37.6 in). Tighten locknut (5) to 12 ± 4 N·m (9 ± 3 lb ft).

2. Loosen setscrew locknut and turn **out** setscrews (12), (13) and (14). Turn setscrew (18) all the way in.

3. Move throttle lever (17) to the shutoff (vertical position). Turn setscrew (12) **in** to adjust lever (16) to dimension (V) of 27.5 ± 1.0 mm (1.08 ± .04 in) and tighten locknut to 25 ± 7 N·m (20 ± 5 lb ft).

4. Install rod (2) between levers (4) and (16). With throttle lever (17) in shutoff (vertical position) adjust rod (2) to obtain dimension (W) for lever (4). Tighten locknut (3) to 12 ± 4 N·m (9 ± 3 lb ft).

5. With governor control shaft (10) at shutoff position, install control group (11) so that the mounting hole in plate (7) is at 30 ± 5 degrees to the left of vertical as shown.

6. Install rod (6). Any necessary adjustments to install the rod should be made at rod end (9) attached to plate (7). Tighten locknut (8) to 12 ± 4 N·m (9 ± 3 lb ft).

7. Move throttle lever (17) toward **High Idle** until forward movement of rod (6) stops.

8. Turn setscrew (18) **out** until it makes contact with the stop on throttle lever (17). Now turn setscrew (18) **in** one turn and tighten locknut to a torque of 25 ± 7 N·m (20 ± 3 lb ft).

NOTE: This adjustment allows full travel of governor shaft, but gives a positive stop after full linkage travel.

9. With throttle lever (17) in **High Idle** position, turn setscrew (14) **in** until there is 2 ± 1 mm (.08 ± .04 in) clearance between roller in lever (15) and lever (16). Tighten locknut on setscrew (14) to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

NOTE: This adjustment makes sure that **High Idle** can be reached using throttle lever (17) without interference with the decelerator linkage.

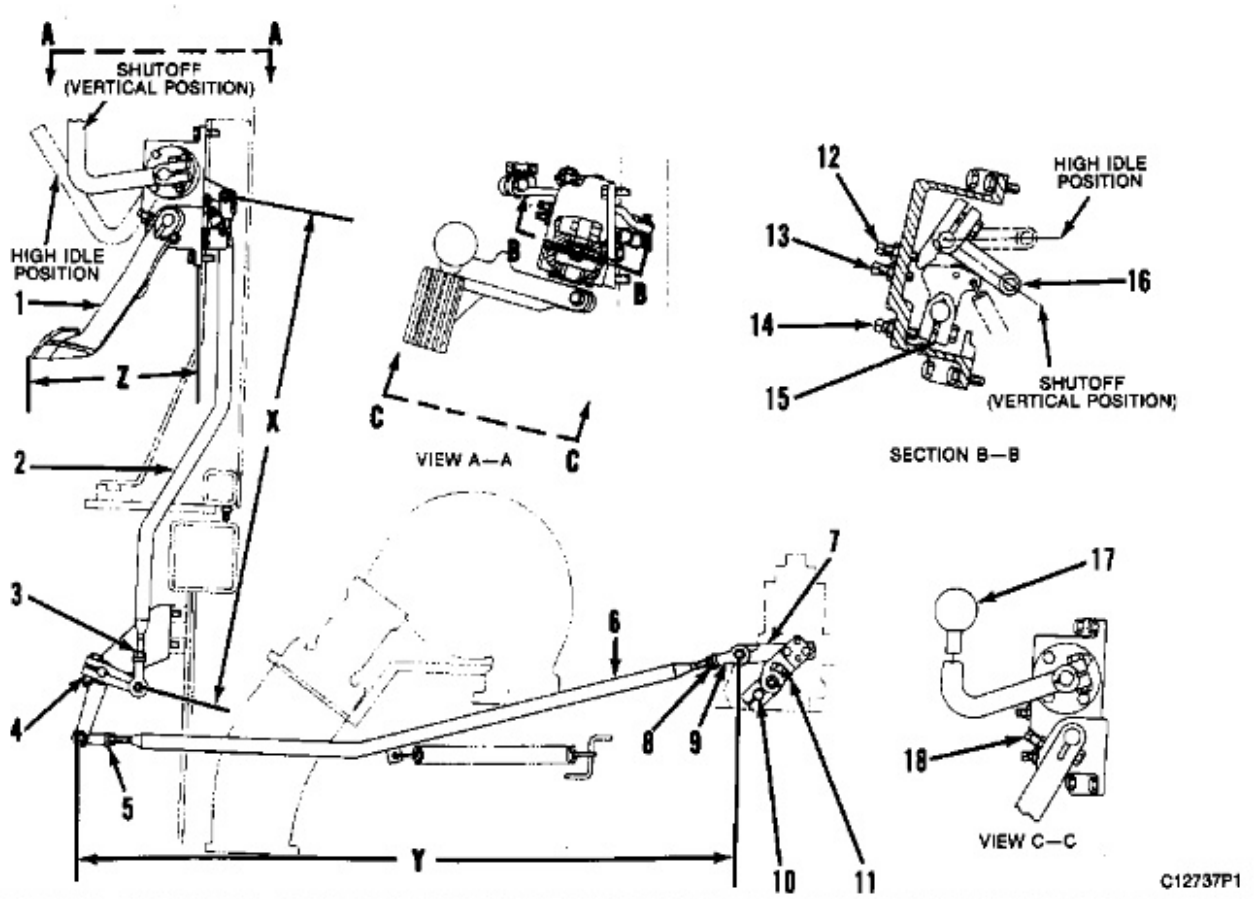
10. Adjust, if necessary, decelerator pedal (1) on the splined shaft to obtain dimension (Z) of 241 ± 17 mm (9.5 ± .7 in).

11. Start engine and move throttle lever (17) to **High Idle.** Turn setscrew (13) **in** far enough so that, when decelerator pedal (1) is depressed, contact is made with setscrew (13) at an engine speed of 1000 ± 50 rpm. When this adjustment is correct, tighten locknut to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

12. Release decelerator pedal (1) and check **High Idle** setting according to the Fuel Setting And Related Information Fiche.

Governor Control Adjustments

D8L (Later)



Adjusting Governor Control
(1) Decelerator pedal. (2) Rod. (3) Locknut. (4) Lever. (5) Locknut. (6) Rod. (7) Plate. (8) Locknut. (9) Rod end. (10) Governor shaft. (11) Control group. (12) Setscrew. (13) Setscrew. (14) Setscrew. (15) Lever. (16) Lever. (17) Throttle lever. (18) Setscrew. (X) 720 ± 2 mm (28.3 ± .1 in) dimension. (Y) 956 mm (37.6 in) dimension. (Z) 241 ± 17 mm (9.5 ± .7 in) dimension.

1. Adjust rod (2) to a dimension (X) of 720 ± 2 mm (28.3 ± 1 in). Tighten locknut (3) to 12 ± 4 N·m (9 ± 3 lb ft). Then adjust rod (6) to an approximate dimension (Y) of 956 mm (37.6 in).

2. Loosen setscrew locknuts and turn out setscrews (12), (13) and (14). Turn setscrew (18) all the way in.

3. Disconnect rod end (9) from plate (7) and move throttle lever (17) to vertical position (shutoff).

4. With governor shaft (10) at shutoff position, put control group (11) on governor shaft splines so that mounting hole in plate (7) is at 30 ± 5 degrees to the left of vertical.

5. Connect rod (6) to plate (7). Any necessary adjustment to make this connection are to be made at rod end (9). Tighten locknut (8) to 12 ± 4 N·m (9 ± 3 lb ft).

6. Move throttle lever (17) toward High Idle until the forward movement of lever (4) and rod (6) stops.

7. Turn setscrew (18) out until it makes contact with stop on throttle lever (17). Now turn setscrew (18) in one turn and tighten locknut to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

NOTE: This adjustment allows full travel of governor shaft, but gives a positive stop for amount of linkage travel.

8. With throttle lever in the High Idle position, turn setscrew (14) to provide a 2 ± 1 mm (.078 ± .039 in) gap between roller bearing in lever (15) and lever (16).

NOTE: This adjustment makes sure that High Idle can be reached using throttle lever (17) without interference of decelerator pedal (1).

9. Remove and install pedal (1) on the governor shaft splines so that correct position of tread surface is at a dimension (Z) of 241 ± 17 mm (9.5 ± .7 in). Tighten the bolt that holds pedal to shaft.

10. Move throttle lever (17) to shutoff position. Turn setscrew (12) **in** until it contacts inside lever, then turn setscrew (12) **out** one turn. Tighten the locknut to 25 ± 7 N·m (20 ± 5 lb ft).

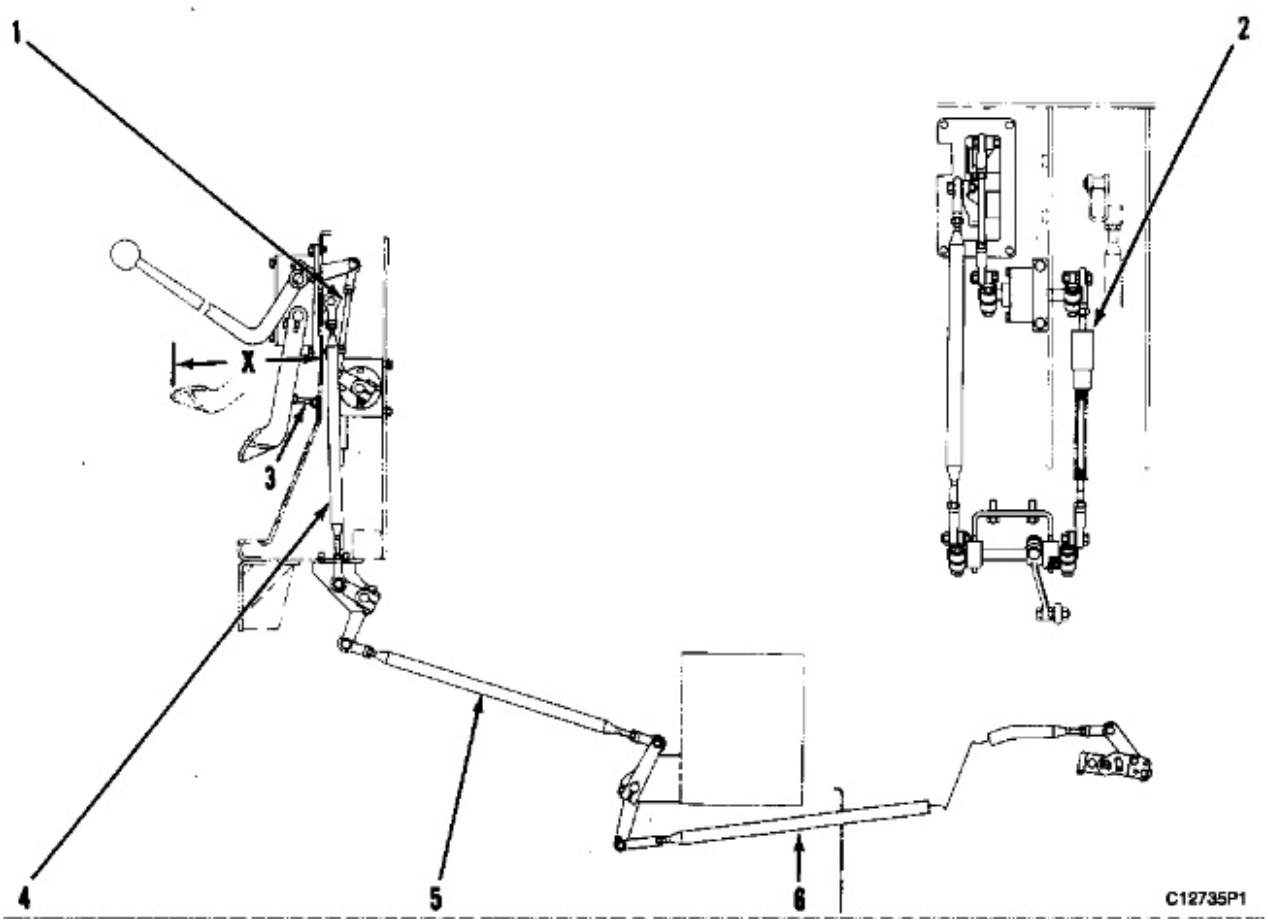
NOTE: This adjustment lets governor shaft move to full shutoff position, but provides a positive stop so that linkage cannot go too far.

11. Start engine and move throttle lever (17) to High Idle. Turn setscrew (13) **in** far enough so that, when decelerator pedal (1) is depressed, contact is made with setscrew (13) at an engine speed of 1000 ± 50 rpm. When this adjustment is correct, tighten locknut to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

12. Move throttle lever (17) back to High Idle position and check High Idle setting according to Fuel Setting And Related Information Fiche.

Governor Control Adjustments

589



Adjusting Governor Control
(1) Rod assembly. (2) Link assembly. (3) Pedal bolt. (4) Rod assembly. (5) Rod assembly. (6) Dimension (X) 260 ± 10 mm (10.2 ± 0.4 in).

The procedure to adjust the governor control to High Idle is as follows in Steps 1-5.

1. Adjust rod assembly (6) to a dimension of 1180 ± 3 mm (46.4 ± .1 in)

2. Adjust rod assembly (5) to a dimension of 510 ± 3 mm (20.0 ± .1 in)

3. Adjust rod assembly (4) to a dimension of 485 ± 3 mm (19.1 ± .1 in)

4. Link assembly (2) must be adjusted to an overall length of 371 ± 3 mm (14.6 ± .1 in)

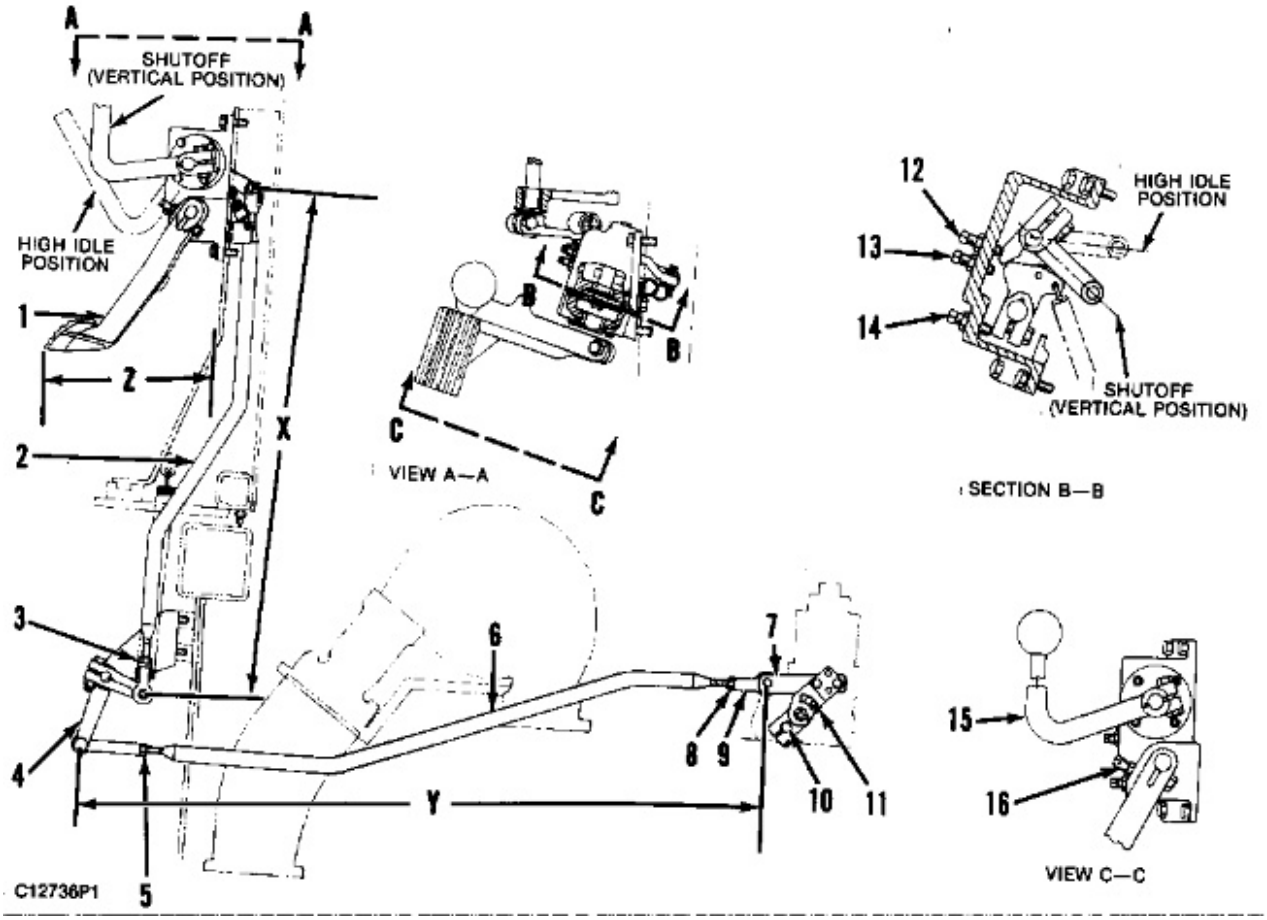
5. Adjust rod assembly (1) to a dimension of 171 ± 3 mm (6.7 ± .1 in). Tighten all locknuts to a torque of 12 ± 4 N·m (9 ± 3 lb ft).

6. The dimension X from the front tread of pedal to the dash wall is 260 ± 10 mm (10.2 ± 0.4 in). This is the governor control to shut off.

7. Check the Fuel Setting and Related Information Fiche to determine engine rpm for specific applications. Start engine and adjust pedal bolt (3) against the dash wall to obtain the specified High Idle setting.

Governor Control Adjustments

D9N (Earlier)



Adjusting Governor Control
(1) Declerator pedal. (2) Rod. (3) Locknut. (4) Lever. (5) Locknut. (6) Rod. (7) Plate. (8) Locknut. (9) Rod end. (10) Governor shaft. (11) Control group. (12) Setscrew. (13) Setscrew. (14) Setscrew. (15) Throttle lever. (16) Setscrew. (X) 720 ± 2 mm (28.3 ± .08 in) dimension. (Y) 959 mm (37.8 in) dimension. (Z) 241 ± 17 mm (9.5 ± .7 in) dimension.

1. Adjust rod (2) to a dimension (X) of 720 ± 2 mm (28.3 ± .08 in). Tighten locknut (3) to 12 ± 4 N·m (9 ± 3 lb ft). Then adjust rod (6) to an approximate dimension (Y) of 959 mm (37.8 in). Tighten locknut (5) to 12 ± 4 N·m (9 ± 3 lb ft).

2. Loosen setscrew locknuts and turn **out** setscrews (12), (13), and (14). Turn setscrew (16) all the way **in.**

3. Disconnect rod end (9) from plate (7) and move throttle lever (15) to vertical position (shutoff).

4. With governor shaft (10) at shutoff position, put control group (11) on governor shaft splines so that mounting hole in plate (7) is at 30 ± 5 degrees to the left of vertical.

5. Connect rod (6) to plate (7). Any necessary adjustments to make this connection are to be made at rod end (9). Tighten locknut (8) to 12 ± 4 N·m (9 ± 3 lb ft).

6. Move throttle lever (15) toward High Idle until the forward movement of lever (4) and rod (6) stops.

7. Turn setscrew (16) **out** until it makes contact with stop on throttle lever (15). Now turn setscrew (16) **in** one turn and tighten locknut to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

NOTE: This adjustment allows full travel of governor shaft, but gives a positive stop for amount of linkage travel.

8. With throttle lever in the High Idle position, turn setscrew (14) **in** until there is 2 to 8 mm (.08 to .31

in) free play at tread end of decelerator pedal (1). Tighten locknut on setscrew (14) to a torque fo 25 ± 7 N·m (20 ± 5 lb ft).

NOTE: This adjustment makes sure that High Idle can be reached using throttle lever (15) without interference of decelerator pedal (1).

9. Remove and install pedal (1) on the governor shaft splines so that correct position of tread surface is at a dimension (Z) of 241 ± 17 mm (9.5 ± .7 in). Tighten the bolt that holds pedal to shaft.

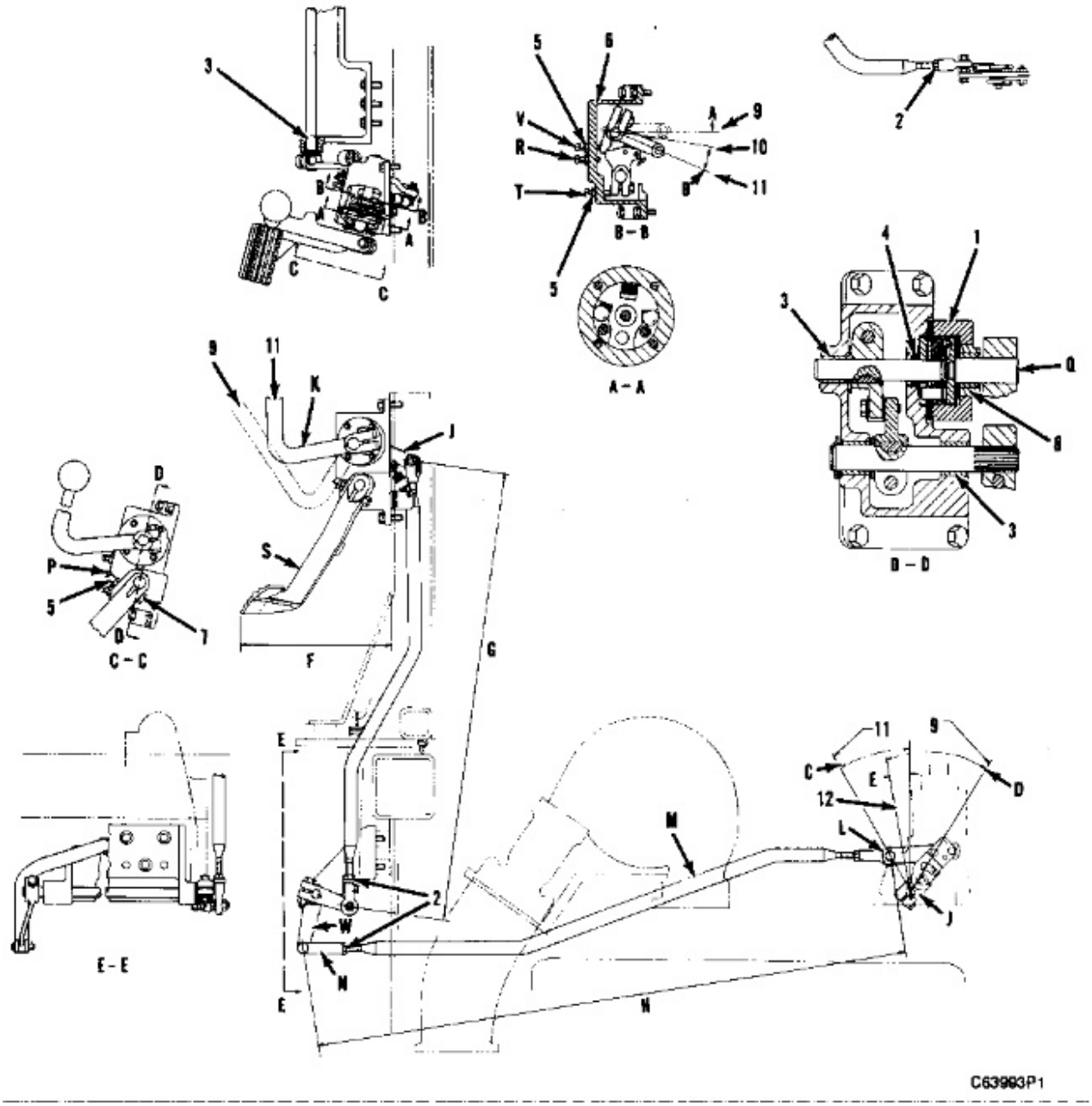
10. Move throttle lever (15) to shutoff position. Turn setscrew (12) **in** until it contacts inside lever, then turn setscrew (12) **out** one turn. Tighten the locknut to 25 ± 7 N·m (20 ± 5 lb ft).

NOTE: This adjustment lets governor shaft move to full shutoff position, but provides a positive stop so that linkage cannot go too far.

11. Start engine and move throttle lever (15) to High Idle. Turn setscrew (13) **in** far enough so that, when decelerator pedal (1) is depressed, contact is made with setscrew (13) at an engine speed of 1000 ± 50 rpm. When this adjustment is correct, tighten locknut to a torque of 25 ± 7 N·m (20 ± 5 lb ft).

12. Move throttle lever (15) back to High Idle position and check High Idle setting according to Fuel Setting And Related Information Fiche.

Governor Control Adjustments D9N (Later)



(1) Detent mechanism. Lubricate all parts of detent mechanism with SAE 10W lubricant.

(2) Nuts. Tighten nuts to a torque of ... 12 ± 4 N·m (9 ± 3 lb ft)

(3) Bearing. Drive on stamped end only.

(4) Seal. Install seal with the sealing lip facing away from detent mechanism. Lubricate seal lip with lubricant being sealed.

(5) Nuts. Tighten nuts to a torque of ... 25 ± 7 N·m (18 ± 5 lb ft)

(6) Housing. Apply black RTV as a gasket.

(7) Bolt. Tighten bolt to a torque of ... 55 ± 7 N·m (40 ± 5 lb ft)

(8) Housing. With linkage disconnected at Lever J, tighten housing until 24.5 ± 1.6 N·m (18.01 ± 1.18 lb ft) is required to rotate Shaft Q.

(9) High idle.

(10) Horizontal.

(11) Shutoff.

(12) Low idle.

(A) 12 degrees.

(B) 22 degrees.

(C) 30 ± 5 degrees.

(D) 42 degrees.

(E) 10 degrees.

(F) Length ... 241.0 ± 17.0 mm (9.49 ± .67 in)

(G) Length ... 720.0 ± 2.0 mm (28.35 ± .08 in)

(H) Length ... 959.0 mm (37.76 in)

The following is the governor control group adjustment procedure:

Setscrews V (shutoff), R (decel rpm), T (pedal stop) backed off, Setscrew P fully engaged with all locknuts loose.

1. With linkage disconnected from Lever W, position Lever K in the vertical shutoff position.

2. Position Control Group J so that the mounting hole on Lever Assembly L is 30 ± 5 degrees from vertical with governor in shutoff position.

3. Connect Rod Assembly M to Lever W by adjusting Rod End N.

4. Move Lever K toward High Idle, until the forward movement of Lever W and Rod M stops, then back out Setscrew P to contact Lever K, turn in one full turn and lock.

5. With Control Lever K still in High Idle Position, turn in and lock Setscrew T (Pedal Stop) to allow 5.00 ± 3.00 mm (.197 ± .118 in) free play at the end of pedal.

6. Adjust Pedal S in splined shaft to position tread surface to dimension shown.

7. Move Control Lever K to the shutoff position, turn in Setscrew V (shutoff) until it contacts internal lever, back off one turn and lock.

8. With the engine running at high idle, turn in and lock Setscrew R (DCLR RPM) so that engine decelerates to 1000 ± 50 RPM when pedal is depressed. When pedal is released, recheck high idle RPM.

Air Inlet And Exhaust System

Restriction Of Air Inlet And Exhaust

There will be a reduction of horsepower and efficiency of the engine if there is a restriction in the air inlet or exhaust system.

Air flow through the air cleaner must not have a restriction (negative pressure difference measurement between atmospheric air and air that has gone through air cleaner) of more than 762 mm (30 in) of water.

Back pressure from the exhaust (pressure difference measurement between exhaust at outlet elbow and atmospheric air) must not be more than 685 mm (27 in) of water.

Measurement Of Pressure In Inlet Manifold

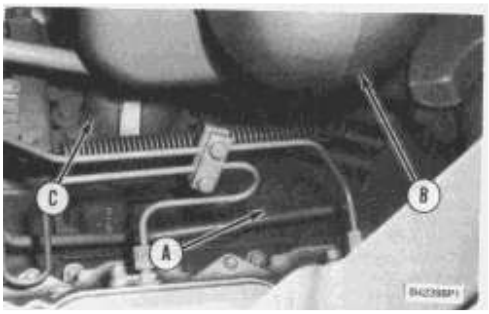
The efficiency of an engine can be checked by making a comparison of the pressure in the inlet manifold with the information given in the Fuel Setting And Related Information Fiche. This test is used when there is a decrease of horsepower from the engine, yet there is no real sign of a problem with the engine.

The correct pressure for the inlet manifold is given in the Fuel Setting And Related Information Fiche. Development of this information is done with these conditions:

a. 747 mm (29.4 in) of mercury barometric pressure.
b. 29°C (85°F) outside air temperature.
c. 35 API rated fuel

Any change from these conditions can change the pressure in the inlet manifold. Outside air that has higher temperature and lower barometric pressure than given above will cause a lower horsepower and a lower inlet manifold pressure measurement than given in the Fuel Setting And Related Information Fiche. Outside air that has a lower temperature and a higher barometric pressure will cause higher horsepower and a higher inlet manifold pressure measurement.

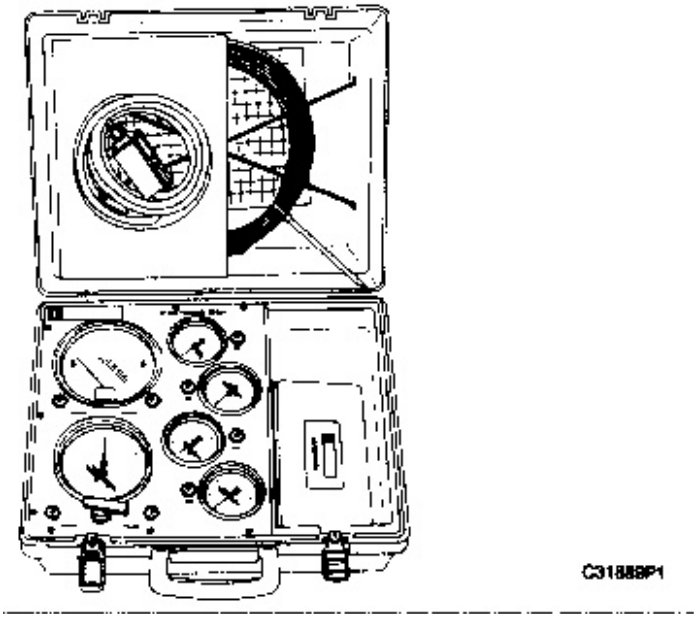
A difference in fuel rating will also change horsepower and the pressure in the inlet manifold. If the fuel is rated above 35 API, pressure in the inlet manifold can be less than given in the Fuel Setting And Related Information Fiche. If the fuel is rated below 35 API, the pressure in the inlet manifold can be more than given in the Fuel Setting And Related Information Fiche. Be Sure That The Air Inlet And Exhaust Do Not Have A Restriction When Making A Check Of Pressure In The Inlet Manifold.



Plug For Pressure Test
(A) Plug. (B) Exhaust elbow. (C) Pipe to inlet manifold.

Use the 1U5470 Engine Pressure Group to check the pressure in the inlet manifold.

Remove plug (A) on inlet pipe to measure inlet manifold pressure.



1U5470 Engine Pressure Group

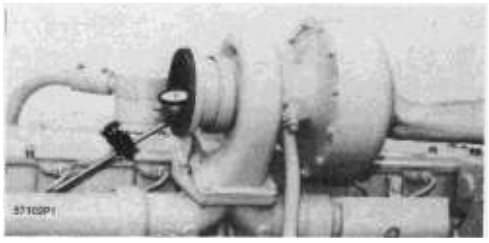
This tool group has a gauge to read pressure in the inlet manifold. Special Instruction Form No. SEHS8907 is with the tool group and gives instructions for its use.

Turbocharger

Every 7200 hours or if any unusual sound or vibration in the turbocharger is noticed, a quick check of bearing condition can be made without disassembling the turbocharger. This can be done by removing the piping from the turbocharger and inspecting the compressor impeller, turbine wheel and compressor cover. Rotate the compressor and turbine wheel assembly by hand and observe by feeling excess end play. The rotating assembly should rotate freely with no rubbing or binding. If there is any indication of the impeller rubbing the compressor cover or the turbine wheel rubbing the turbine housing, recondition the turbocharger or replace with a new or rebuilt one.

End clearance is best checked with a dial indicator. Attach a dial indicator with the indicator point on the end of the shaft. Move the shaft from end to end making note of the total indicator reading.

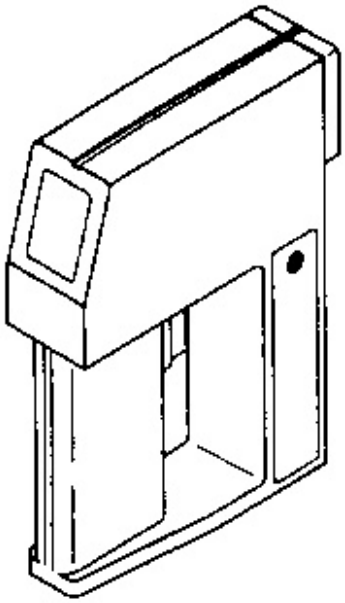
End play for TL81 Turbochargers should be 0.08 to 0.25 mm (.003 to .010 in). If end play is more than the maximum end play rebuild or replace the turbocharger. End play less than the minimum end play could indicate carbon build up on the turbine wheel and the turbocharger should be disassembled for cleaning and inspection.



Checking Turbocharger Rotating Assembly End Play (Typical Example)

A more reliable check of bearing conditions can be made only when the turbocharger is disassembled and the bearings, shaft journal and housing bore diameters can actually be measured.

Exhaust Temperature



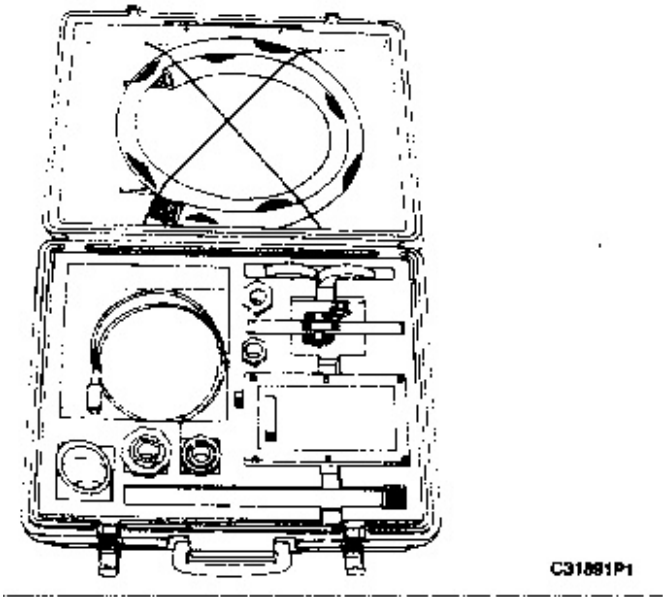
1U8865 Infrared Thermometer Group

Use the 1U8865 Infrared Thermometer Group to check exhaust temperature. Special Instruction Form No. NEHS0510 is with the tool group and gives instructions for the test procedure.

Crankcase (Crankshaft Compartment) Pressure

Tools Needed		
8T2700	Indicator Group	1

Pistons or rings that have damage can be the cause of too much pressure in the crankcase. This condition may cause the engine to run rough. There will also be more than the normal amount of fumes (blowby) coming from the crankcase breather. The breather can then become restricted in a very short time, causing oil leakage at gaskets and seals that would not normally have leakage. Other sources of blowby can be worn valve guides or turbocharger seal leakage.



8T2700 Indicator Group

The 8T2700 Indicator Group is used to check the amount of blowby. The test procedure is in Special Instruction, Form No. SEHS8712.

Compression

An engine that runs rough can have a leak at the valves, or have valves that need adjustment. Use the test that follows for a fast and easy method to find a cylinder that has low compression, or does not have good fuel combustion. Find the speed that the engine runs the roughest, and keep the engine at this rpm until the test is finished. Loosen the fuel line nut at a fuel injection pump to stop the flow of fuel to that cylinder. Do this for each cylinder until a loosened fuel line is found that makes no difference in engine performance. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. This test can also be an indication that the fuel injection is wrong, so the cylinder will have to be checked thoroughly. Removal of the head and inspection of the valves and valve seats is necessary to find those small defects that do not normally cause a problem. Repair of these problems is normally done when reconditioning the engine.

Cylinder Head

The cylinder head has valve seat inserts and valve guides that can be removed when they are worn or have damage. Replacement of these components can be made with the tools that follow.

Valves

Valve removal and installation is easier with use of the 9U7241 Valve Spring Compressor Group and 5S1322 Valve Keeper Inserter.

Valve Seat Inserts

Tools needed to remove and install valve seat inserts are in the 6V4805 Valve Insert Puller Group. Additional tooling needed to install seats are the 9U6898 Driver-Valve Seat (exhaust) and 9U6897 Driver-Valve Seat (inlet). Special Instruction, Form No. SMHS7935 gives an explanation for the procedure to remove the valve seat inserts. For easier installation, lower the temperature of the insert before it is installed in the head.

Valve Guides

Tools needed to remove and install valve guides are the 9U6895 Driver-Valve Guide and 9U6894 Collar Guide. The counterbore in the driver bushing installs the guide to the correct height. Use a 1P7451 Valve Guide Honing Group to make a finished bore in the valve guide after installation of the guide in the head. Special Instruction, Form No. SMHS7526 gives an explanation for this procedure. Grind the valves after the new valve guides are installed.

Checking Valve Guide Bores

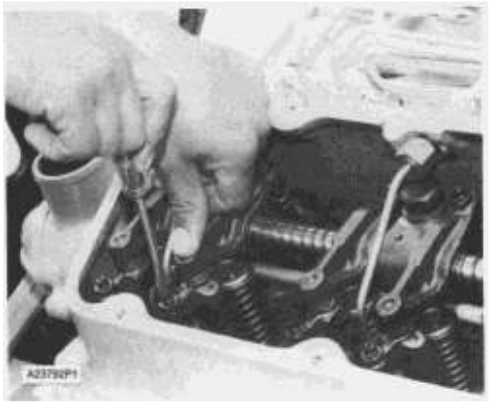
Use the 5P3536 Valve Guide Gauge Group to check the bore of the valve guides. Special Instruction, Form No. GMG02562 gives complete and detailed instructions for use of the 5P3536 Valve Guide Gauge Group.

Bridge Dowel

Use a 5P0944 Dowel Puller Group with a 5P0942 Extractor to remove the bridge dowels. Install a new bridge dowel with a 5P2406 Dowel Driver. This dowel driver installs the bridge dowel to the correct height.

Bridge Adjustment

When the head is disassembled, keep the bridges with their respective cylinders. Adjustment of the bridge will be necessary after the valves are ground or other reconditioning of the cylinder head is done. The bridge should be checked and/or adjusted each time the valves are adjusted. Use the procedure that follows to make an adjustment to the bridge.



Bridge Adjustment

NOTE: Valves must be fully closed.

1. Put engine oil on the bridge dowel in the cylinder head and in the bore in the bridge.

2. Install the bridge with the adjustment screw toward the exhaust manifold.

3. Loosen the locknut for the adjustment screw and loosen the adjustment screw several turns.

4. Put a force on the bridge with a finger to keep the bridge in contact with the valve stem opposite the adjustment screw.

5. Turn the adjustment screw clockwise until it just makes contact with the valve stem. Then turn the adjustment screw 30 degrees more in a clockwise direction to make the bridge straight on the dowel,

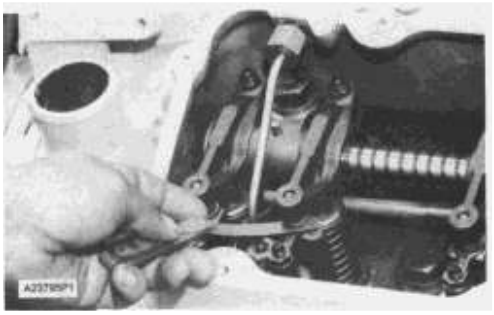
and to make compensation for the clearance in the threads of the adjustment screw.

6. Hold the adjustment screw in this position and tighten the locknut to 28 ± 4 N·m (22 ± 3 lb ft).

7. Put engine oil at the point where the rocker arm makes contact with the bridge.

Valve Lash Setting

NOTE: Valve lash is measured between the rocker arm and the bridge for the valves.

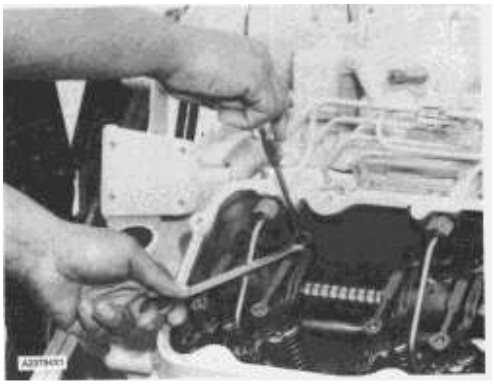


Valve Lash

NOTE: Intake and exhaust valve lash adjustments should be made at the first recommended oil change.

Valve Lash Setting: Engine Stopped
Exhaust.....0.76 mm (.030 in)
Intake.....0.38 mm (.015 in)

To make an adjustment to the valve lash, turn the adjustment screw in the rocker arm. Valve lash adjustments can be made by using the procedure that follows:



Valve Adjustment (Typical Illustration)

1. Put No. 1 piston at top center (TC) on the compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston.

2. Make an adjustment to the valve lash on the intake valves for cylinders 1, 2, 5 and 7. Make an adjustment to the valve lash on the exhaust valves for cylinders 1, 3, 4, and 8.

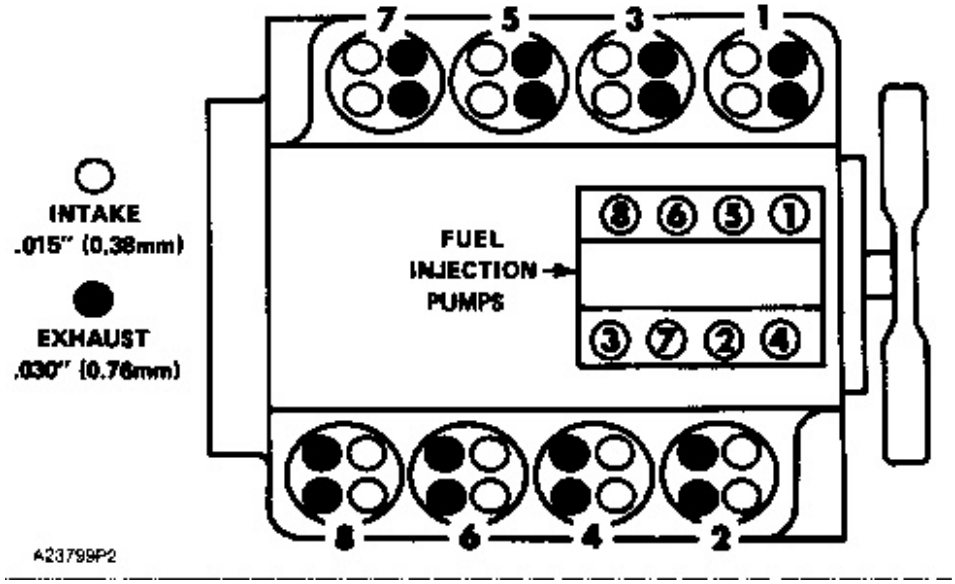
3. After each adjustment, tighten the nut for valve adjustment screw to 28 ± 4 N·m (22 ± 3 lb ft), and check the adjustment again.

4. Remove the timing bolt and turn the flywheel 360 degrees in the direction of engine rotation. This will put No. 6 piston at top center (TC) on the compression stroke. Install the timing bolt in the flywheel.

5. Make an adjustment to the valve lash on the intake valves for cylinders 3, 4, 6 and 8. Make an adjustment to the valve lash on the exhaust valves for cylinders 2, 5, 6 and 7.

6. After each adjustment, tighten the nut for valve adjustment screw 28 ± 4 N·m (22 ± 3 lb ft), and check the adjustment again.

7. Remove the timing bolt from the flywheel when all valve clearances are correct.



Cylinder And Valve Location

Lubrication System

One of the problems in the list that follows will generally be an indication of a problem in the lubrication system for the engine.

Too Much Oil Consumption

Oil Pressure Is Low

Oil Pressure Is High

Too Much Bearing Wear

Increased Oil Temperature

Too Much Oil Consumption

Oil Leakage on Outside of Engine

Check for leakage of the seals at each end of the crankshaft. Look for leakage at the oil pan gasket and all lubrication system connections. Check to see if oil comes out of the crankcase breather. This can be caused by combustion gas leakage around the pistons. A dirty crankcase breather will cause high pressure in the crankcase, and this will cause gasket and seal leakage.

Oil Leakage Into Combustion Area of Cylinders

Oil leakage into the combustion area of the cylinders can be the cause of blue smoke. There are four possible ways for oil leakage into the combustion area of the cylinders:

1. Oil leakage between worn valve guides and valve stems.
2. Worn or damaged piston rings, or dirty oil return holes.
3. Compression ring and/or intermediate ring not installed correctly.
4. Oil leakage past the seal rings in the impeller end of the turbocharger shaft.

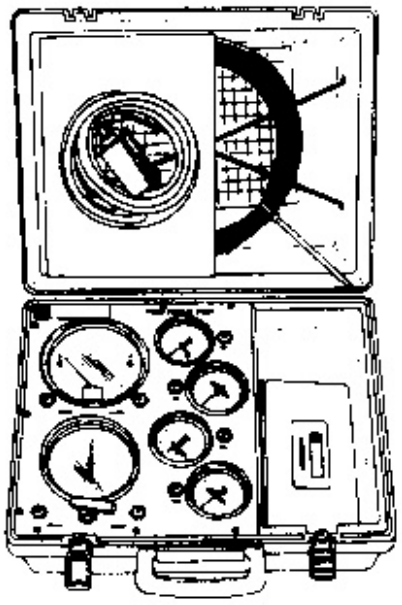
Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

Measuring Engine Oil Pressure

Tools Needed		
1U5470	Engine Pressure Group	1

An oil pressure gauge that has a defect can give an indication of low oil pressure.

The 1U5470 Engine Pressure Group can be used to check engine oil pressure.



1U5470 Engine Pressure Group

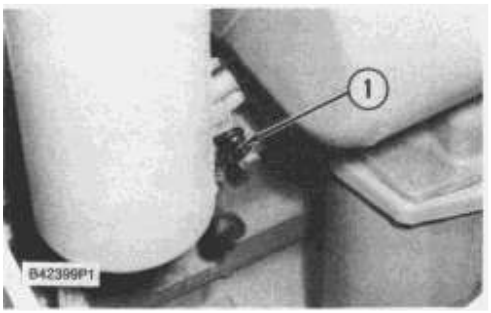
This tool group has a gauge to read oil pressure in the engine. Special Instruction, Form No. SEHS8907 is with the tool group and gives instructions for the test procedure.

1. Be sure that the engine is filled to the correct level with SAE 10W-30 or 15W-40 oil. If any other

viscosity of oil is used, the information in the Engine Oil Pressure Graph does not apply.

2. Connect the 1U5470 Engine Pressure Group to the main oil manifold at location (1).

3. Operate the engine to get it up to normal operating temperature.

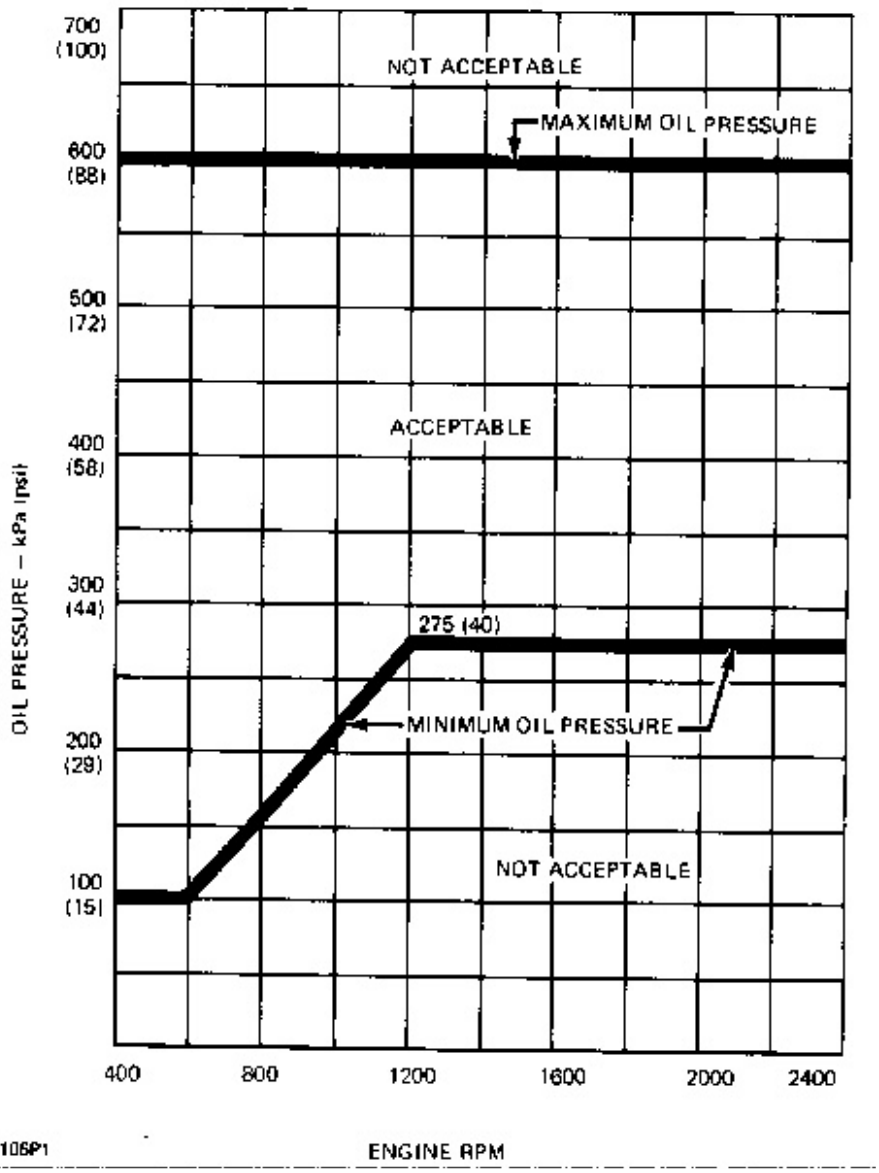


Oil Manifold
(1) Pressure test location

4. Keep the oil temperature constant with the engine at its rated rpm, and read the pressure gauge.

NOTE: Make sure engine oil temperature does not go above 115°C (239°F).

5. On the Engine Oil Pressure Graph, find the point that the lines for engine rpm and oil pressure intersect (connect).



Engine Oil Pressure Graph

6. If the results do not fall within the "Acceptable" pressure range given in the graph, find the cause and correct it. Engine failure or a reduction in engine life can be the result if engine operation is continued with oil manifold pressure outside this range.

NOTE: A record of engine oil pressure, kept at regular intervals, can be used as an indication of possible engine problems or damage. If there is a sudden increase of decrease of 70 kPa (10 psi) in oil pressure, even though the pressure is in the "Acceptable" range on the graph, the engine should be inspected and the problem corrected.

Oil Pressure Is Low

Crankcase Oil Level

Check the level of the oil in the crankcase. Add oil if needed. It is possible for the oil level to be too far below the oil pump supply tube. This will cause the oil pump to not have the ability to supply enough lubrication to the engine components.

Oil Pump Does Not Work Correctly

The inlet screen of the supply tube for the oil pump can have a restriction. This will cause cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) and a loss of oil pressure. Air leakage in the supply side of the oil pump will also cause cavitation and loss of oil pressure. If the bypass valve for the oil pump is held in the open (unseated) position, the lubrication system can not get to maximum pressure. Oil pump gears that have too much wear will cause a reduction in oil pressure.

Oil Filter Bypass Valves

If the bypass valve for the oil filter is held in the open position (unseated) because the oil filter has a restriction, a reduction in oil pressure can result. To correct this problem, remove and clean the bypass valve and bypass valve bore. Install a new Caterpillar oil filter to be sure that no more debris makes the bypass valve stay open.

Too Much Clearance At Engine Bearings Or Open Lubrication System (Broken Or Disconnected Oil Line Or Passage)

Components that are worn and have too much bearing clearance can cause oil pressure to be low. Low oil pressure can also be caused by an oil line or oil passage that is open, broken or disconnected.

Piston Cooling Tubes (Jets)

When engine is operated, cooling jets direct oil toward the bottom of the piston to lower piston and ring temperatures. If there is a failure of one of the jets, or it is bent in the wrong direction, seizure of the piston will be caused in a very short time.

Use the 5P8709 Piston Tool Group to check and adjust the alignment of piston cooling jets.

Oil Pressure Is High

Oil pressure will be high if the bypass valve for the oil pump can not move from the closed position.

Too Much Bearing Wear

When some components of the engine show bearing wear in a short time, the cause can be a restriction in an oil passage. A broken oil passage can also be the cause.

If the gauge for oil pressure shows enough oil pressure, but a component is worn because it can not get enough lubrication, look at the passage for oil supply to the component. A restriction in a supply passage will not let enough lubrication get to a component, and this will cause early wear.

Increased Oil Temperature

Look for a restriction in the oil and coolant passages of the oil cooler. If the oil cooler has a restriction, the oil temperature will be higher than normal when the engine is operated. The oil pressure of the engine will not get low just because the oil cooler has a restriction.

Also check the oil cooler bypass valve to see if it is held in the open position (unseated). This condition will let the oil through the valve instead of the oil cooler, and oil temperature will increase.

Cooling System

This engine has a pressure type cooling system. A pressure type cooling system gives two advantages.

The first advantage is that the cooling system can have safe operation at a temperature that is higher than the normal boiling (steam) point of water. The second advantage is that this type system prevents cavitation (low pressure bubbles suddenly made in liquids by mechanical forces) in the water pump. With this type system, it is more difficult for an air or steam pocket to be made in the cooling system.

The cause for increased engine temperature is generally because regular inspections of the cooling system were not made. Make a visual inspection of the cooling system before a test is made with test equipment.

Visual Inspection To The Cooling System

1. Check coolant level in the cooling system.

2. Look for leaks in the system.

NOTE: Water pump seals. A small amount of coolant leakage across the surface of the "face-type" seals is normal, and required, to provide lubrication for this type of seal. A hole is provided in the water pump housing to allow this coolant/seal lubricant to drain from the pump housing. Intermittent leakage of small amounts of coolant from this hole is not an indication of water pump seal failure. Replace the water pump seals only if a large amount of leakage, or a constant flow of coolant is observed draining from the water pump housing.

3. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.

4. Inspect the drive belts for the fan.

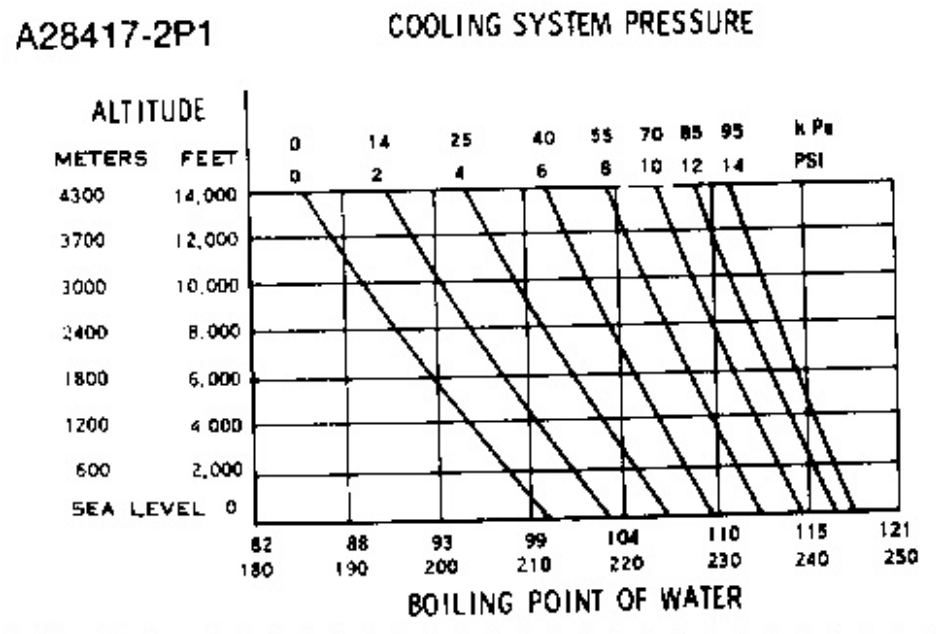
5. Check for damage to the fan blades.

6. Look for air or combustion gas in the cooling system.

7. Inspect the filler cap and the surface that seals the cap. This surface must be clean.

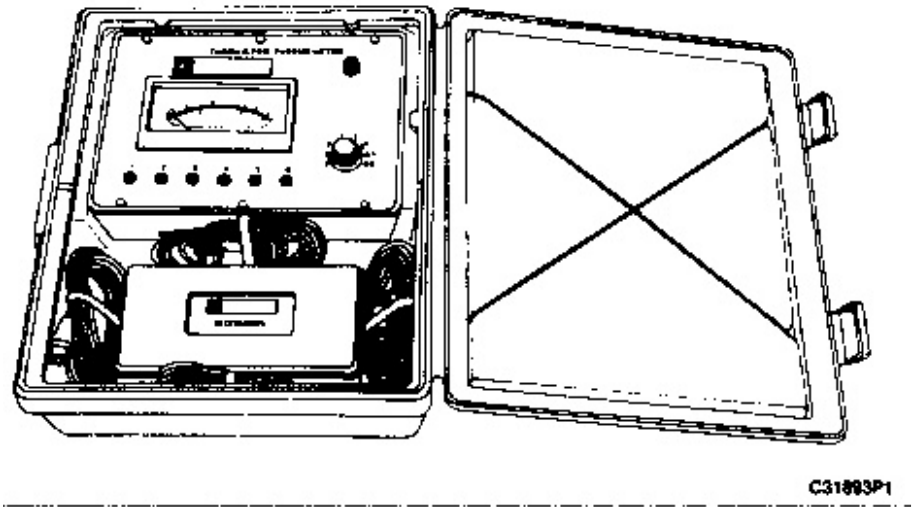
Testing The Cooling System

Remember that temperature and pressure work together. When a diagnosis is made of a cooling system problem, temperature and pressure must both be checked. Cooling system pressure will have an effect on cooling system temperatures. For an example, look at the chart to see the effect of pressure and height above sea level on the boiling (steam) point of water.



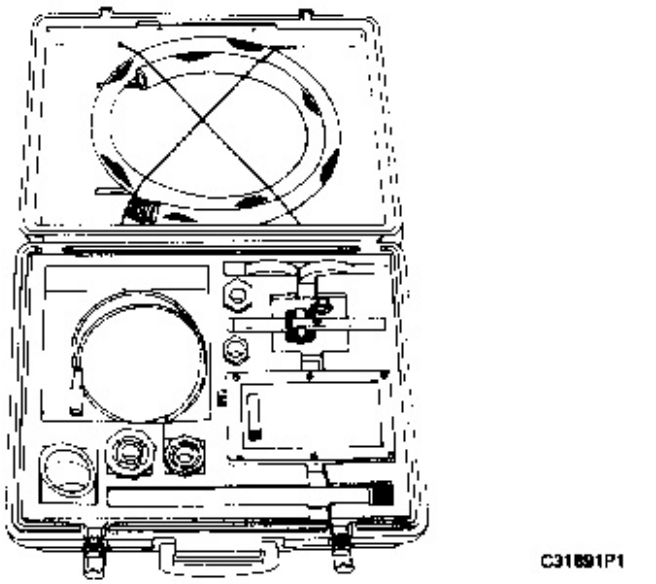
Test Tools For Cooling System

Tools Needed		
4C6500	Digital Thermometer Group	1
8T2700	Indicator Group	1
6V3121	Multitach Group	1
9S8140	Cooling System Pressurizing Pump Group	1



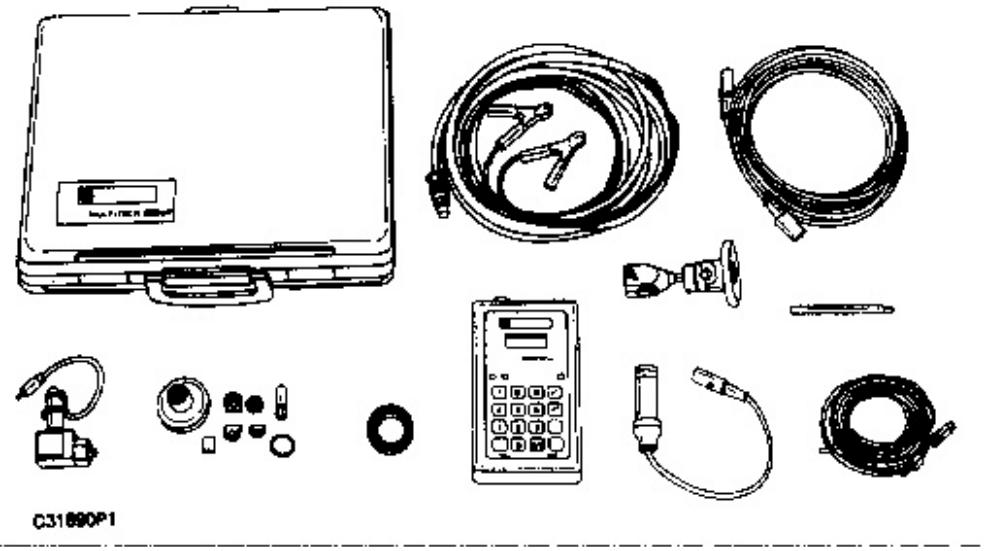
4C6500 Digital Thermometer Group

The 4C6500 Digital Thermometer Group is used in the diagnosis of overheating (engine hotter than normal) or overcooling (engine cooler than normal) problems. This group can be used to check temperatures in several different parts of the cooling system. The testing procedure is in Operating Manual, Form No. NEHS0554.



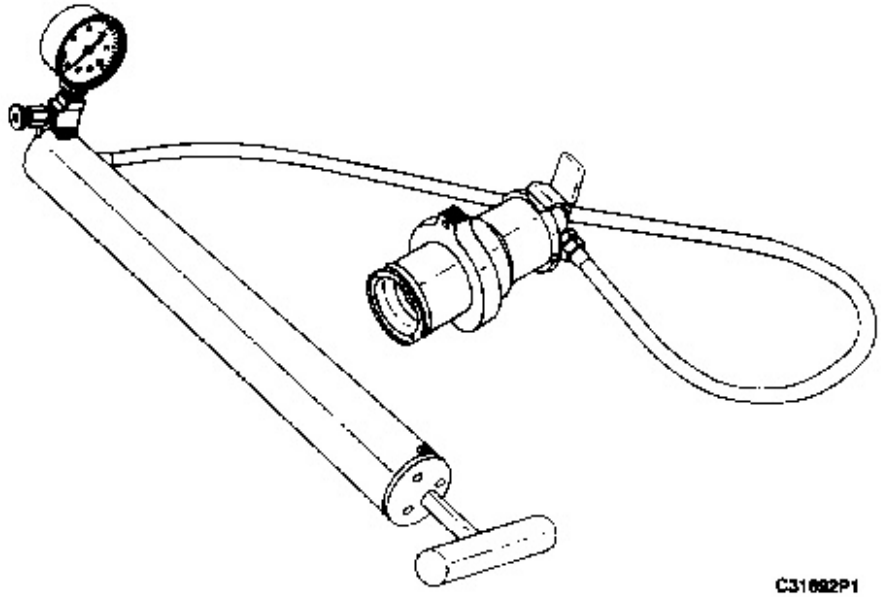
8T2700 Blowby/Air Flow Indicator Group

The 8T2700 Blowby/Air Flow Indicator Group is used to check the air flow through the radiator core. The test procedure is in Special Instruction, Form No. SEHS8712.



6V3121 Multitach Group

The 6V3121 Multitach Group is used to check the fan speed. The testing procedure is in Special Instruction, Form SEHS7807.

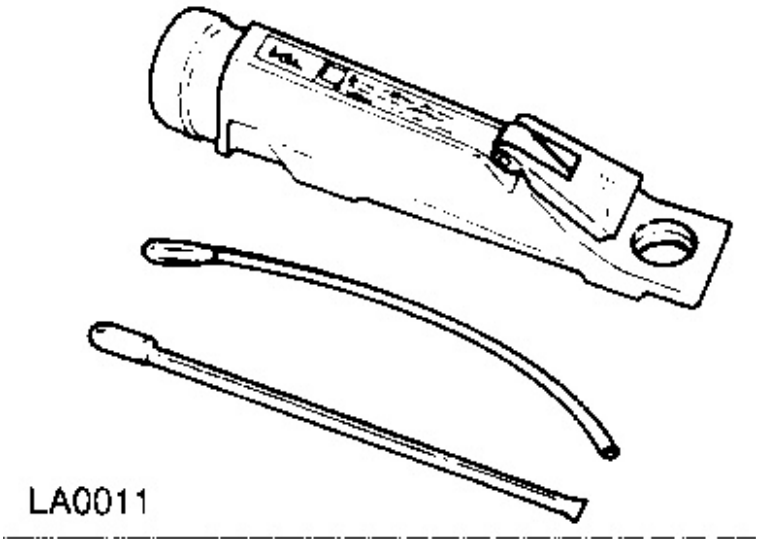


9S8140 Cooling System Pressurizing Pump Group

The 9S8140 Cooling System Pressurizing Pump Group is used to test pressure caps and to pressure check the cooling system for leaks.

WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.



5P0957 Or 5P3514 Coolant Tester

Check the coolant solution frequently in cold weather for glycol concentration with the 5P0957 or 5P3514 Coolant Tester to ensure adequate protection. Both testers are used for checking coolant freezing point, and are identical except temperature scale. They give immediate, accurate readings and can be used for antifreeze/coolants that contain etylene or propylene glycol.

Make Proper Antifreeze Additions

Adding pure antifreeze as a makeup solution for cooling system top-off is an unacceptable practice. It increases the concentration of antifreeze in the cooling system which increases the concentration of dissolved solids and undissolved chemical inhibitors in the cooling system. Add antifreeze mixed with acceptable water to the same freeze protection as your cooling system. Use the chart as follows to assist in determining the concentration of antifreeze to use.

ANTIFREEZE CONCENTRATIONS	
Protection Temperature	**Concentration**
Protection to −15°C (5°F)	30% antifreeze and 70% water
Protection to −23°C (−10°F)	40% antifreeze and 60% water
Protection to −37°C (−34°F)	50% antifreeze and 50% water
Protection to −51°C (−60°F)	60% antifreeze and 40% water

Checking Pressure Cap

Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

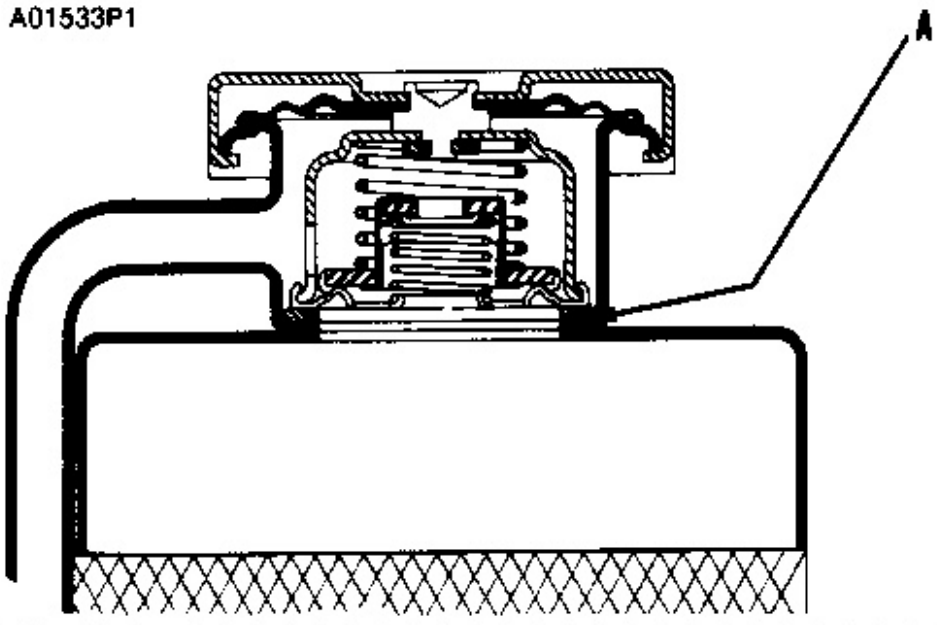
One cause for a pressure loss in the cooling system can be a defective seal on the radiator pressure cap.

WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

After the engine is cool, loosen the pressure cap and let the pressure out of the cooling system. Then remove the pressure cap.

A01533P1



Typical Schematic Of Pressure Cap
(A) Sealing surface of cap and radiator.

Inspect the pressure cap carefully. Look for damage to the seal or to the surface that seals. Any foreign material or deposits on the cap, seal or surface that seals, must be removed.

The 9S8140 Cooling System Pressurizing Pump Group is used to test pressure caps and to pressure check the cooling system for leaks.

WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

To check the pressure cap for the pressure that makes the pressure cap open, use the procedure that follows:

1. Remove the pressure cap from the radiator.

2. Put the pressure cap on the 9S8140 Cooling System Pressurizing Pump Group.

3. Look at the gauge for the exact pressure that makes the pressure cap open.

4. Make a comparison of the reading on the gauge with the correct pressure at which the pressure cap must open.

NOTE: The correct pressure that makes the pressure cap open is on the pressure cap and is also in the Specifications module.

5. If the pressure cap is defective, install a new pressure cap.

Testing Radiator And Cooling System For Leaks

Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

To test the radiator and cooling system for leaks, use the procedure that follows:

WARNING

DO NOT loosen the filler or pressure cap on a hot engine. Steam or hot coolant can cause severe burns.

1. Remove the pressure cap from the radiator.

2. Make sure the coolant is over the top of the radiator core.

3. Put the 9S8140 Cooling System Pressurizing Pump Group on the radiator.

4. Operate the pump group and get a pressure reading on the gauge that is 20 kPa (3 psi) more than the

pressure marked on the pressure cap.

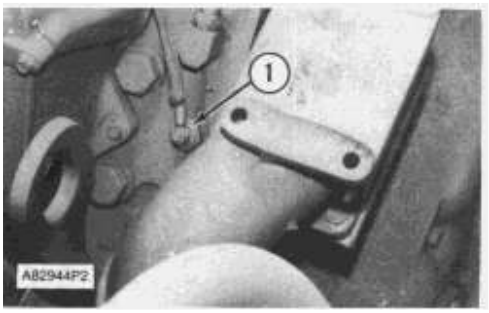
5. Check the radiator for outside leakage.

6. Check all connections and hoses for the cooling system for outside leakage.

7. If you do not see any outside leakage and the pressure reading on the gauge is still the same after five minutes, the radiator and cooling system does not have leakage. If the reading on the gauge goes down and you do not see any outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary.

Gauge For Water Temperature

Tools Needed		
4C6500	Digital Thermometer Group	1
	or	
2F7112	Thermometer	1

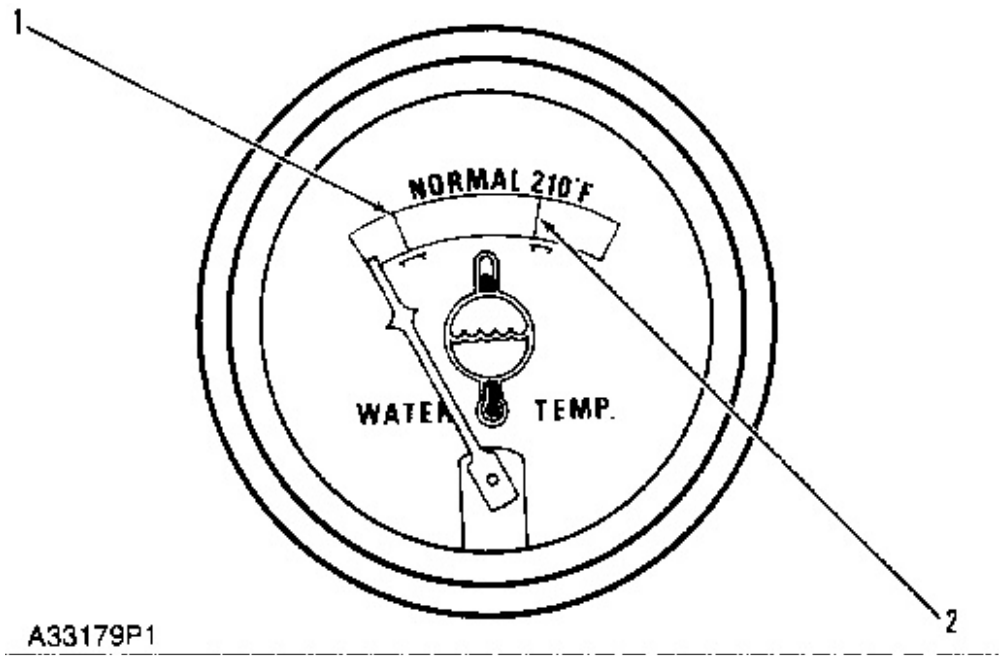


Water Temperature Connection
(1) Sending unit.

If the engine gets too hot and a loss of coolant is a problem, a pressure loss in the cooling system could be the cause. If the gauge for water temperature shows that the engine is getting too hot, look for coolant leakage. If a place cannot be found where there is coolant leakage, check the accuracy of the gauge for water temperature. A temperature gauge of known accuracy can be connected at the location for sending unit (1) to make this check. Also, the 4C6500 Digital Thermometer Group or the 2F7112 Thermometer and 6B5072 Bushing can be used.

WARNING

Work carefully around an engine that is running. Engine parts that are hot, or parts that are moving, can cause personal injury.



Water Temperature Gauge

Start the engine and run it until the temperature is at the desired range according to the test gauge or thermometer. If necessary, put a cover over part of the radiator or cause a restriction of the coolant flow. The reading on the gauge for water temperature must be the same as the test gauge or thermometer within the tolerance range in the chart.

Pointer Position	Test Thermometer
1	65 to 77°C (150 to 170°F)
2	99 to 103°C (210 to 218°F)

Water Temperature Regulators

1. Remove the regulator from the engine.

2. Heat water in a pan until the temperature is 92°C (197°F). Move the water around in the pan to make it all the same temperature.

3. Hang the regulator in the pan of water. The regulator must be below the surface of the water and it must be away from the sides and bottom of the pan.

4. Keep the water at the correct temperature for ten minutes.

5. After ten minutes, remove the regulator and immediately measure the distance the regulator has opened. The distance must be a minimum of 9.53 mm (.375 in).

6. If the distance is less than 9.53 mm (.375 in), make a replacement of the regulator.

BELT TENSION CHART										
BELT SIZE	WIDTH BELT TOP		WIDTH TOP OF PULLEY GROOVE		BELT TENSION "INITIAL"* GAUGE READING		BELT TENSION "USED"** GAUGE READING		BORROUGHS GAUGE NUMBERS	
	mm	in.	mm	in.	N	lb	N	lb	OLD GAUGE NO.	NEW GAUGE NO.
3/8	10.72	.422	9.65	.380	445 ± 22	100 ± 5	400 ± 22	90 ± 5	BT-33-95	BT-33-97
1/2	13.89	.547	12.70	.500	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-95	BT-33-97
5V	15.88	.625	15.24	.600	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
11/16	17.48	.688	15.88	.625	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
3/4	19.05	.750	17.53	.690	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
15/16	23.83	.983	22.30	.878	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
8K	27.92	1.099			800 ± 22	180 ± 5	489 ± 44	110 ± 10		BT-33-109
MEASURE TENSION OF BELT FARTHEST FROM THE ENGINE										

*"INITIAL" BELT TENSION is for a new belt.
**"USED" BELT TENSION is for a belt which has more than 30 minutes of operation at rated speed of engine. A10232-4P1

Basic Block

Piston Rings

This engine has piston grooves and rings of the Keystone (taper) design. The 8T3150 Keystone Piston Ring Groove Gauge Group is available to check the top two ring grooves in the piston. For correct use of the gauge group see the instruction card that is with the gauge group.

8T3150 KEYSTONE PISTON RING GROOVE GAUGE GROUP

BORE SIZE	TYPICAL ENGINES	GAUGES TO USE	
		TOP GROOVE	INTERMEDIATE GROOVE
4.75"	3300, 1674	B	B
5.4"	D343, 1693	D	D
5.4"	D346, D348, D349	B	A
5.4"	3406, 3408, 3412 (With 1/8" top ring)	A	A
5.4"	3406, 3408, 3412 (With larger top ring)	E	A
5.75"	D342	C	C
6.25"	D353	C	C
170 mm	3508, 3512, 3516	F	F

CHECK GROOVES AT TWO POSITIONS ON MAJOR DIAMETER, 90° FROM EACH PIN BORE. BODY OF GAUGE MUST ALWAYS BE OVER CAST BAND (SEE DRAWINGS).

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Instructions For 8T3150 Keystone Piston Ring Groove Gauge Group

Connecting Rods And Pistons

Use the 7M3978 Piston Ring Expander to remove or install piston rings.

Use the 5P3526 Piston Ring Compressor to install pistons into cylinder block.

Tighten the connecting rod bolts in the step sequence that follows:

1. Put engine oil on bolt threads and contact surfaces of nut and cap.

2. Tighten all bolts to 82 ± 8 N·m (60 ± 6 lb ft).

3. Put a mark on each nut and end of bolt.

4. Tighten each nut 120 ± 5 degrees from the mark.

The connecting rod bearings fit tightly in the bore in the rod. If bearing joints or backs are worn (fretted), check bore size. This can be an indication of wear because of a loose fit.

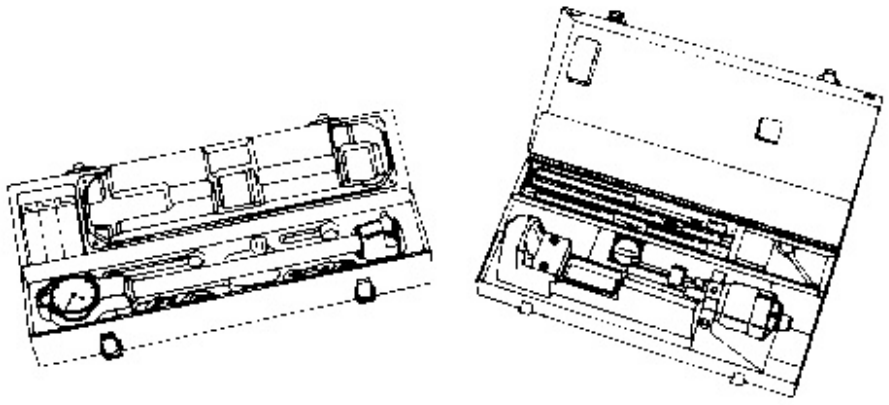
Connecting Rod And Main Bearings

Connecting rod bearings are available with 0.64 mm (.025 in) and 1.27 mm (.050 in) smaller inside diameter than the original size bearings. These bearings are for crankshafts that have been "ground" (made smaller than the original size).

Main bearings are available with a larger outside diameter than the original size bearings. These bearings are for cylinder blocks that have had the bore for the main bearings "bored" (made larger than the original size). The size available is 0.64 mm (.025 in) larger outside diameter than the original size bearings.

Cylinder Block

Tools Needed		
1P3537	Dial Bore Gauge Group	1



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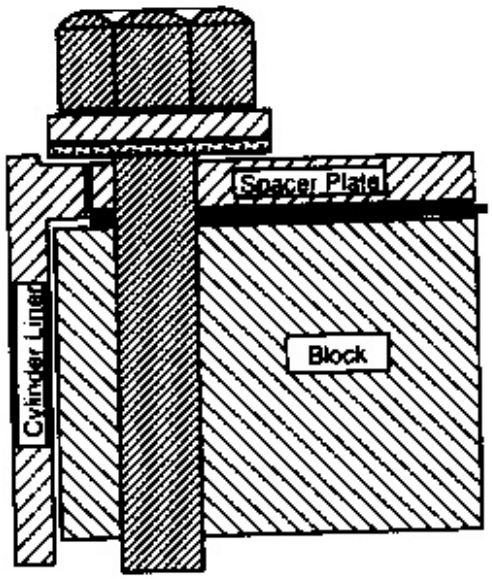
1P3537 Dial Bore Gauge Group

The bore in the block for main bearings can be checked with the main bearing caps installed without bearings. Tighten the nuts that hold the caps to the torque shown in the Specifications module. Alignment error in the bores must not be more than 0.08 mm (.003 in). Special Instruction, Form No. SMHS7606 gives instructions for the use of 1P4000 Line Boring Tool Group for alignment of the main bearing bores. The 1P3537 Dial Bore Gauge Group can be used to check the size of the bores. Special Instruction, Form No. GMG00981 is with the group.

Cylinder Liner Projection



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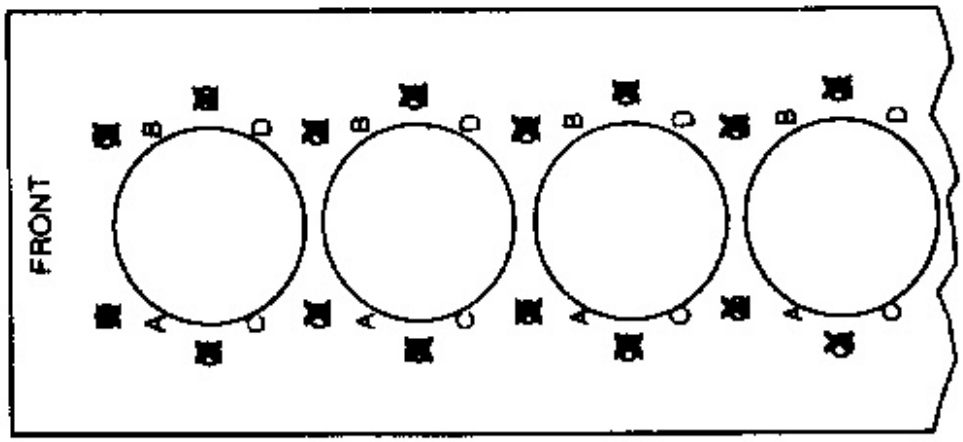
COMPONENTS NEEDED			
Item	Part No	Description	Quanitity For One Cylinder*
1	7H3598	Bolt	6
2	8F1484	Washer	6
3	7K1977**	Washer	6

* The 3408 uses 36 of each of the component piece part.
** These are fabric material washer, an expendable item, therefore you may wish to order more than the amount indicated.

1. Install clean liners or cylinder packs (without the filler band or the rubber seals), spacer plate gasket and clean spacer plate.



C63970P1

2. Install bolts and washers, as indicated previously, in the holes indicated with an X. Install all bolts or the six bolts around the liner. Tighten the bolts to a torque of ... 95 N·m (70 lb ft).

3. Use the 8T0455 Liner Projection Tool Group to measure liner projection at positions indicated with and A,B,C and D. Record measurements for each cylinder. Add the four readings for each cylinder and divide by four to find the average.

4. The cylinder liner specifications are as follows:

Liner projection ... 0.025 to 0.152 mm (0.001 to 0.006 in)

Maximum variation in each cylinder ... 0.051 mm (.002 in)

Maximum average variation between adjacent cylinders ... 0.051 mm (.002 in)

Maximum variation between all cylinders ... 0.102 mm (.004 in)

5. If the liner projections are out of specification, try rotating the liner or install the liner in another bore to see if the measurements improve.

6. If the liner projections are all below the specifications or low in the range, 0.025 mm (0.001 in) or 0.051 mm (0.002 in), try using a thinner spacer plate. These plates are 0.076 mm (.003 in) thinner than the regular plate and they will increase the liner projection, thus increasing the fire ring crush. Use these spacer plates to compensate for low liner projections that are less than 0.076 mm (.003 in) or if the inspection of the top deck reveals no measurable damage directly under the liner flanges, but the average liner projection is less than 0.076 mm (0.003 in).

NOTE: Do not exceed the maximum liner projection of 0.152 mm (.006 in). Excessive liner projection will contribute to liner flange cracking.

7. With the proper liner projection, mark the liners in the proper position and set them aside.

8. When the engine is ready for final assembly, the o-ring seals, cylinder block and upper filler band must be lubricated before installation.

If the lower o-rings are black in color, apply liquid soap on the lower o-ring seals and the cylinder block. Use clean engine oil on the upper filler band.

If the lower o-rings are brown in color, apply engine oil on the lower o-ring seals, the cylinder block and the upper filler band.

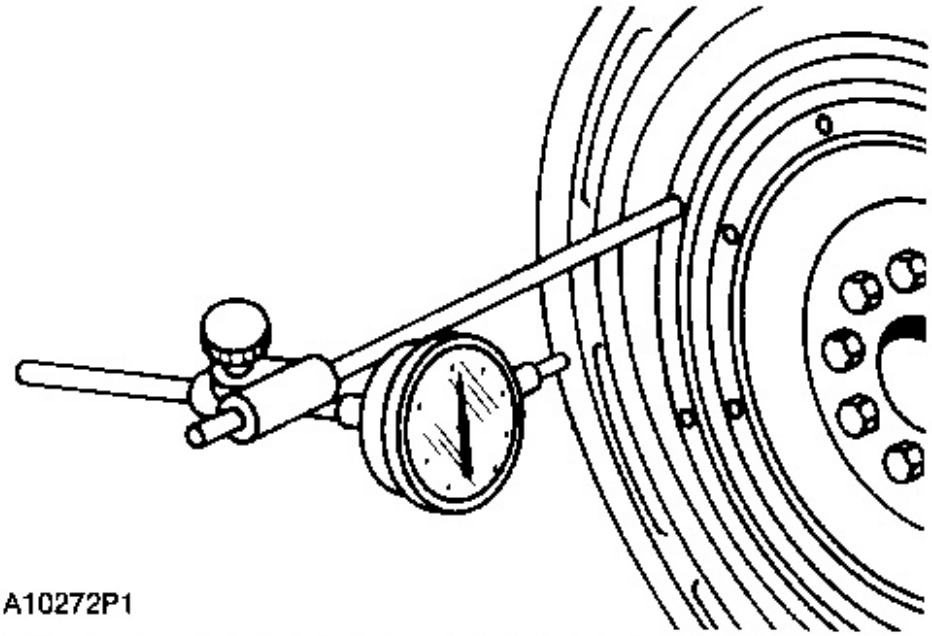
NOTE: Apply liquid soap and/or clean engine oil immediately before assembly. If applied too early, the filler bands may swell and be pinched under the liners during installation.

Flywheel And Flywheel Housing

Tools Needed		
8T5096	Dial Indicator Group	1

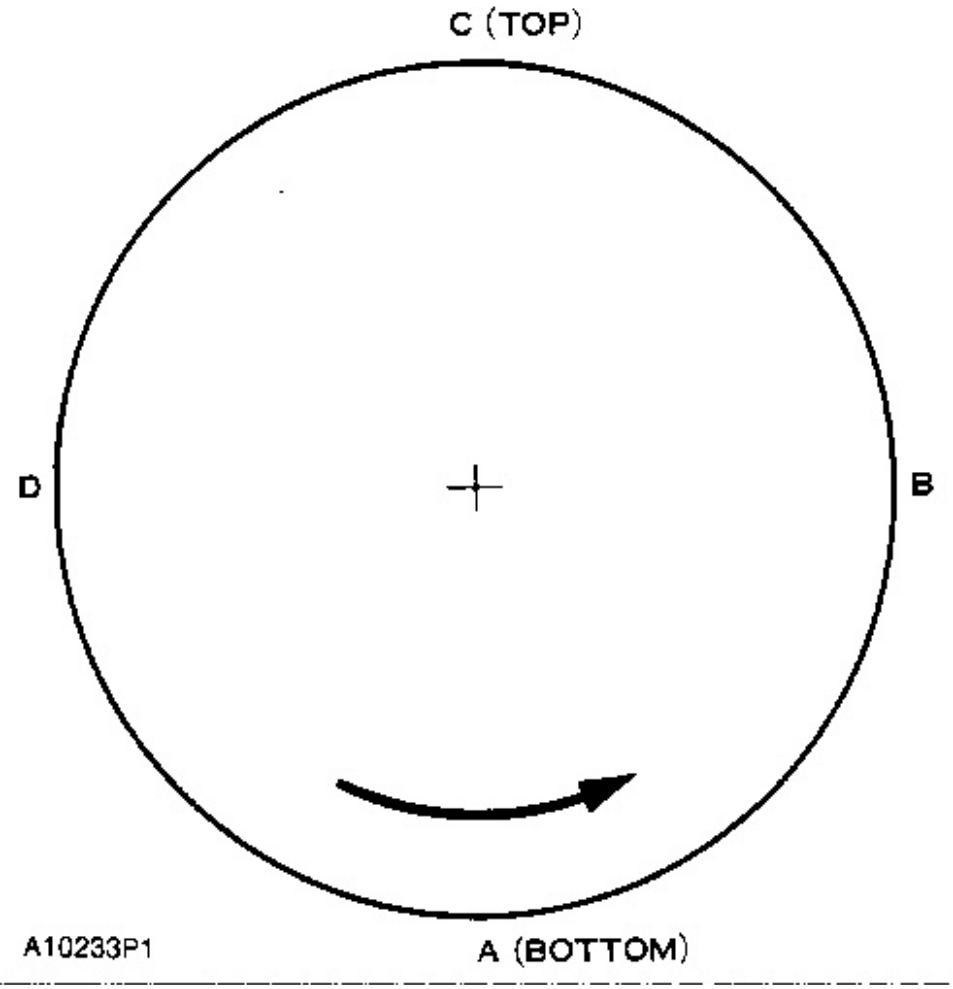
Face Run Out (Axial Eccentricity) Of The Flywheel Housing

If any method other than given here is used, always remember bearing clearance must be removed to get correct measurements.



8T5096 Dial Indicator Group Installed

1. Fasten a dial indicator to the crankshaft flange so the anvil of the indicator will touch the face of the flywheel housing.



Checking Face Runout Of The Flywheel Housing (A) Bottom. (B) Right side. (C) Top. (D) Left side.

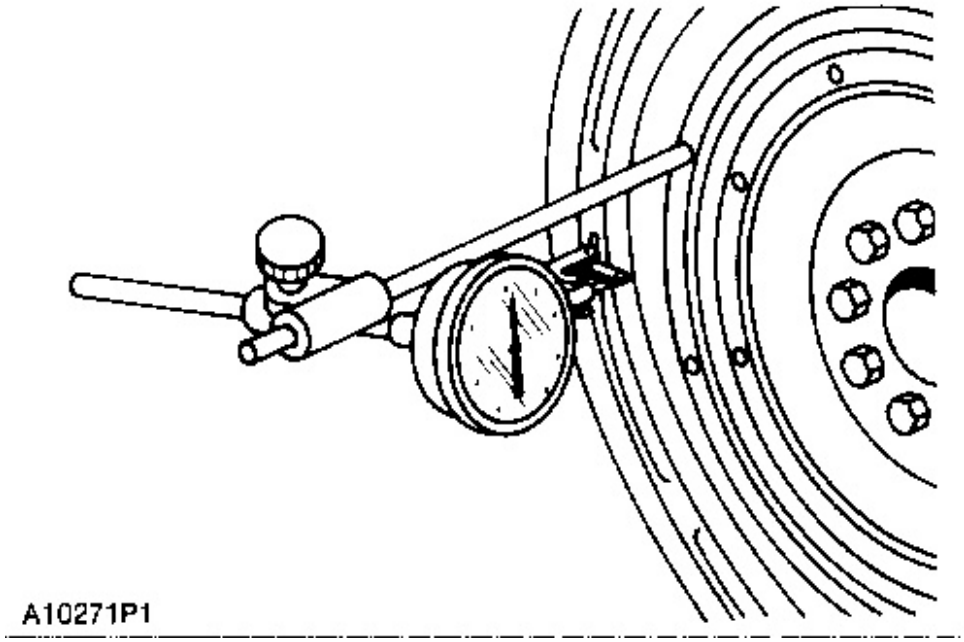
2. Put a force on the crankshaft toward the rear before the indicator is read at each point.

3. With dial indicator set at 0.00 mm (.000 in) at location (A), turn the crankshaft and read the indicator at locations (B), (C) and (D).

4. The difference between lower and higher measurements taken at all four points must not be more than 0.38 mm (.015 in), which is the maximum permissible face runout (axial eccentricity) of the flywheel housing.

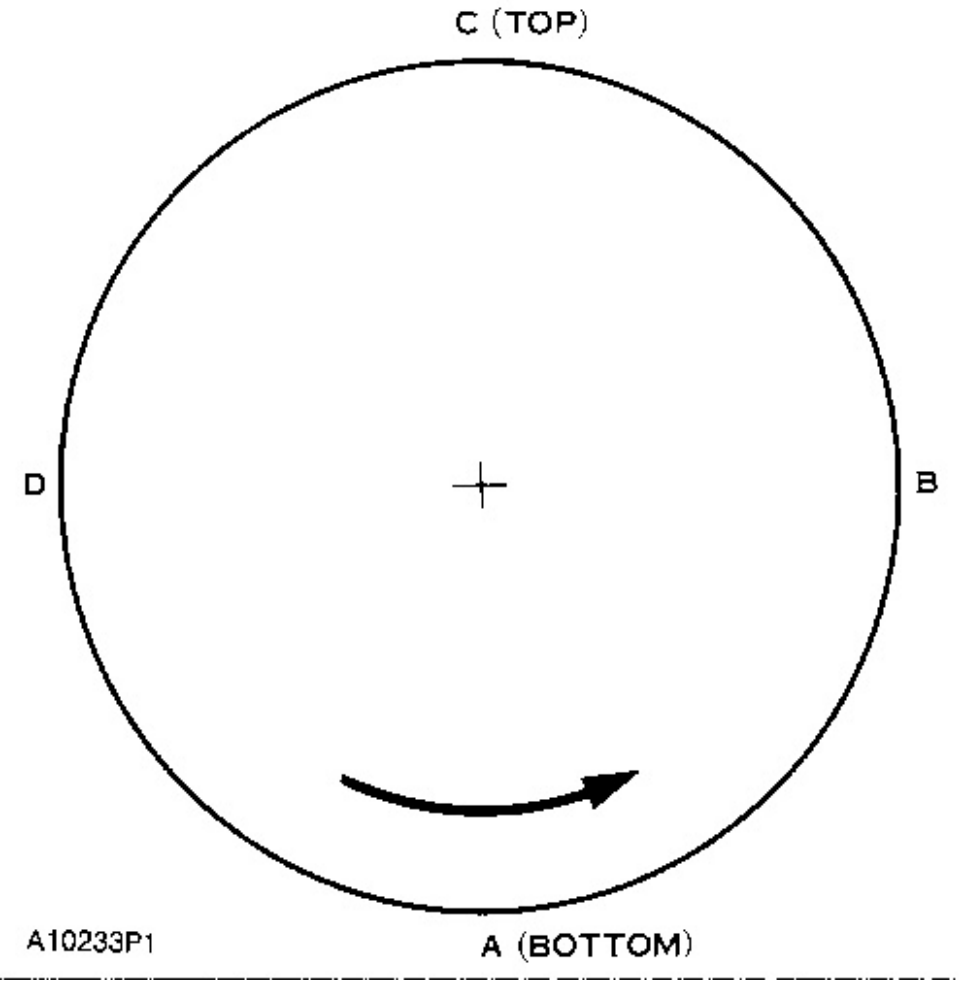
Bore Runout (Radial Eccentricity) Of The Flywheel Housing

1. Fasten the dial indicator as shown so the anvil of the indicator will touch the bore of the flywheel housing.



8T5096 Dial Indicator Group Installed

2. With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crankshaft up against the top of the bearing. Write the measurement for bearing clearance on line 1 in column (C).



Checking Bore Runout Of The Flywheel Housing

NOTE: Write the dial indicator measurements with their positive (+) and negative (-) notation (signs). This notation is necessary for making the calculations in the chart correctly.

3. Divide the measurement from Step 2 by 2. Write this number on line 1 in columns (B) & (D).

4. Turn the crankshaft to put the dial indicator at (A). Adjust the dial indicator to "0" (zero).

5. Turn the crankshaft counterclockwise to put the dial indicator at (B). Write the measurement in the chart.

6. Turn the crankshaft counterclockwise to put the dial indicator at (C). Write the measurement in the chart.

7. Turn the crankshaft counterclockwise to put the dial indicator at (D). Write the measurement in the chart.

CHART FOR DIAL INDICATOR MEASUREMENTS

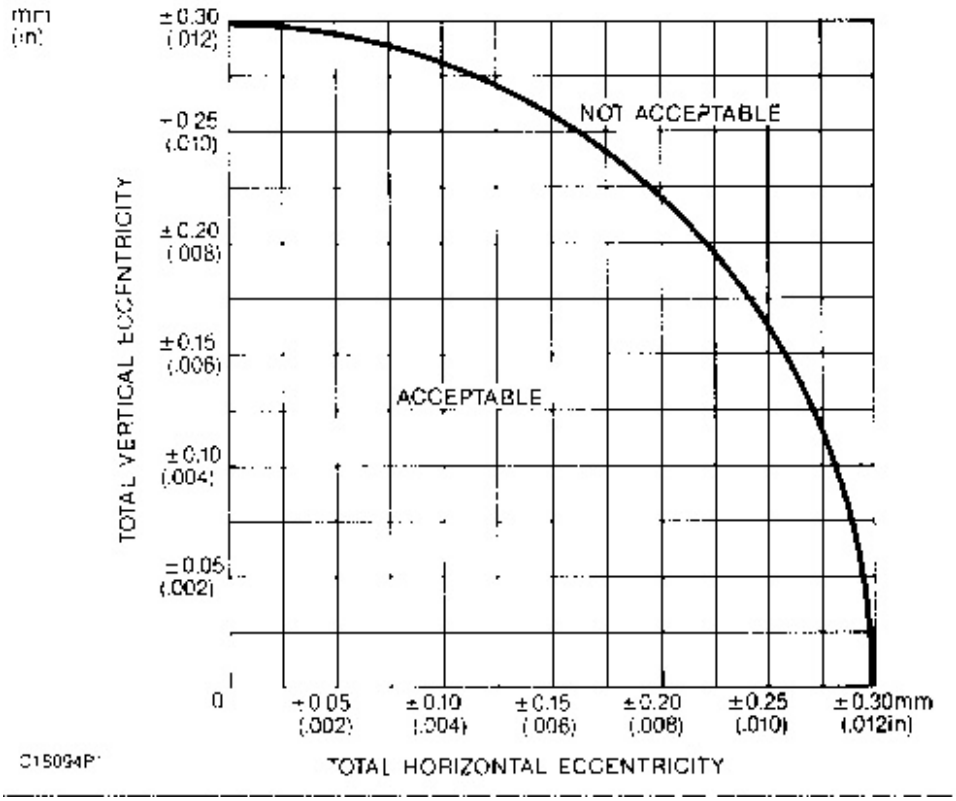
	Position of dial indicator				
	Line No.	A	B	C	D
Correction for bearing clearance	I	0			
Dial Indicator Reading	II	0			
Total of Line 1 & 2	III	0	**	*	**

*Total Vertical eccentricity (out of round).
**Subtract the smaller No. from the larger No. The difference is the total horizontal eccentricity.

A10234P1

8. Add lines I & II by columns.

9. Subtract the smaller number from the larger number in line III in columns (B) & (D). The result is the horizontal eccentricity (out of round). Line III, column (C) is the vertical eccentricity.



Graph For Total Eccentricity

10. On the graph for total eccentricity find the point of intersection of the lines for vertical eccentricity and horizontal eccentricity.

11. If the point of intersection is in the range marked "Acceptable", the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable", the flywheel housing must be changed.

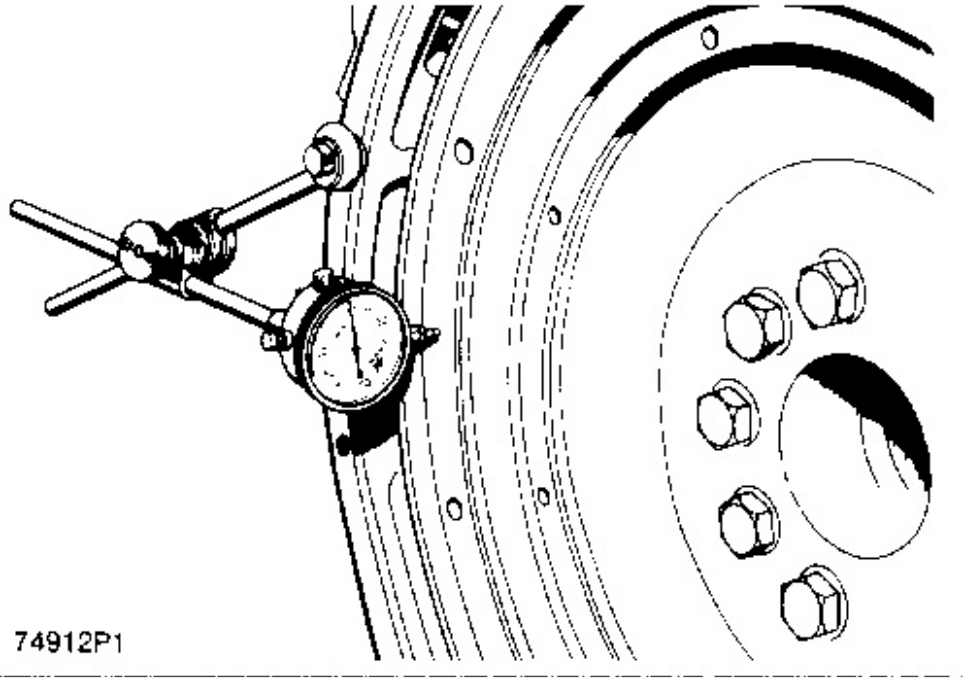
Face Runout (Axial Eccentricity) Of The Flywheel

1. Install the dial indicator as shown. Always put a force on the crankshaft in the same direction before the indicator is read so the crankshaft end clearance (movement) is always removed.

2. Set the dial indicator to read 0.0 mm (.00 in).

3. Turn the flywheel and read the indicator every 90 degrees.

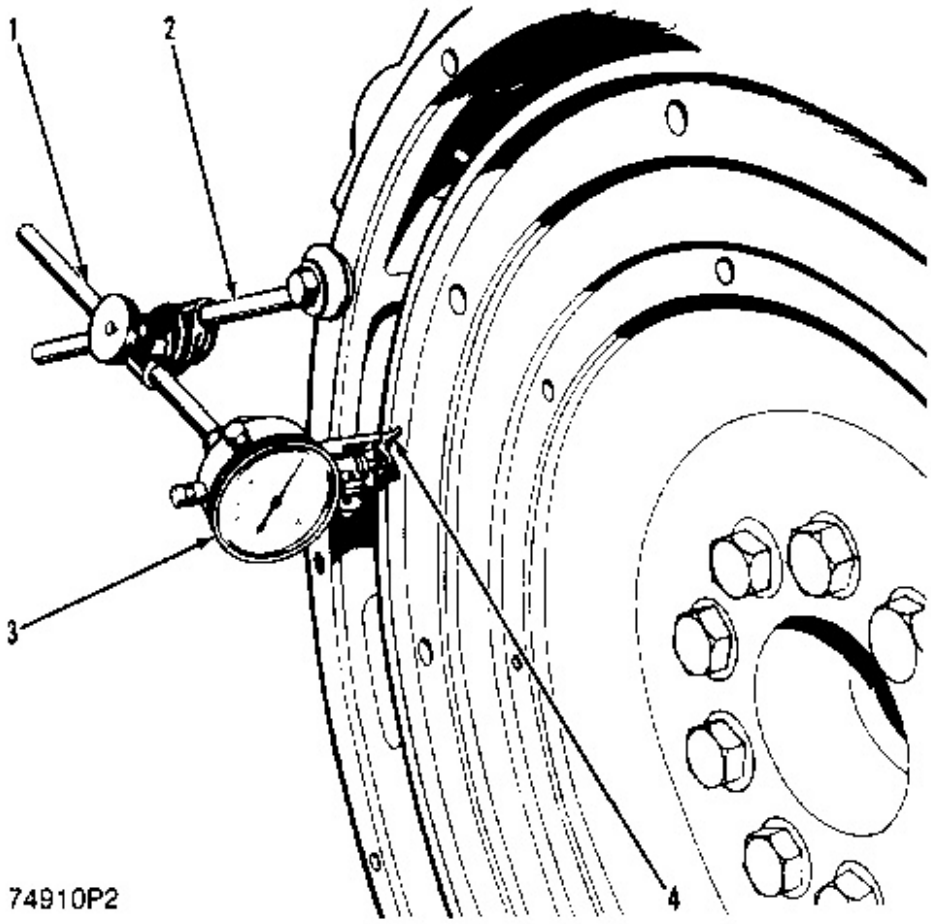
4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in), which is the maximum permissible face runout (axial eccentricity) of the flywheel.



Checking Face Runout Of The Flywheel

Bore Runout (Radial Eccentricity) Of The Flywheel

1. Install the dial indicator (3) and make an adjustment of the universal attachment (4) so it makes contact as shown.

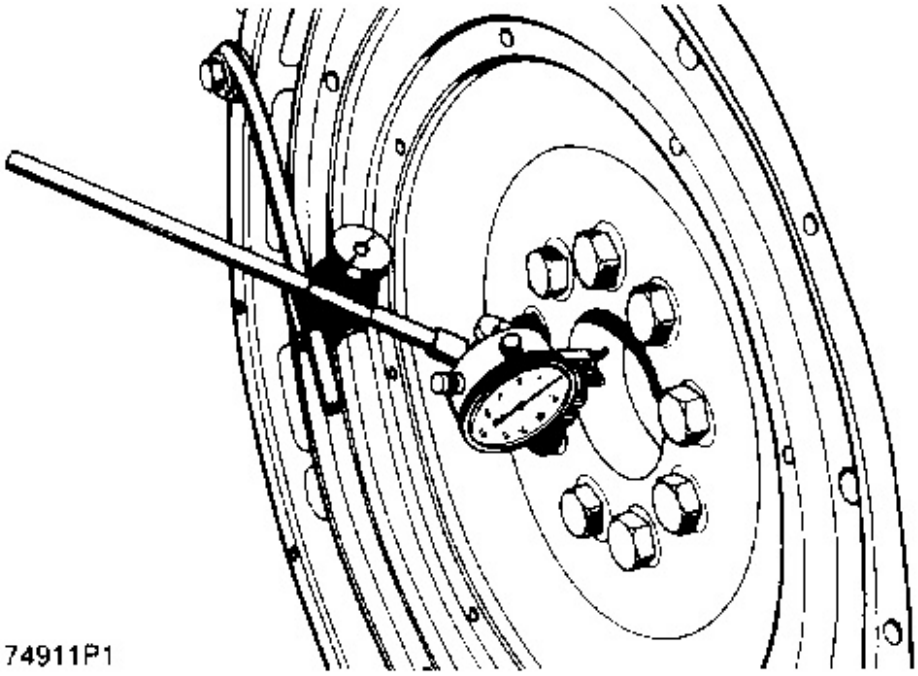


Checking Bore Runout Of The Flywheel
(1) 7H1945 Holding Rod. (2) 7H1645 Holding Rod. (3) 7H1942 Indicator. (4) 7H1940 Universal Attachment.

2. Set the dial indicator to read 0.0 mm (.00 in).

3. Turn the flywheel and read the indicator every 90 degrees.

4. The difference between the lower and higher measurements taken at all four points must not be more than ... 0.15 mm (.006 in)

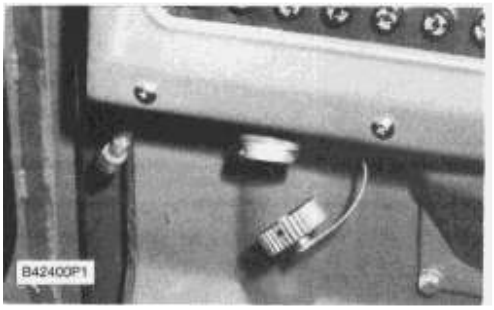


Checking Flywheel Clutch Pilot Bearing Bore

5. Runout (eccentricity) of the bore for the pilot bearing for the flywheel clutch, must not exceed ... 0.13 mm (.005 in)

Electrical System

The engine electrical system on this machine is designed to be tested from a single location with no need to remove sheet metal or covers. An electrical connection called the Diagnostic Connector is located under the dash in the cab. The Diagnostic Connector is connected to 12 major components or circuits of the engine starting and charging system.

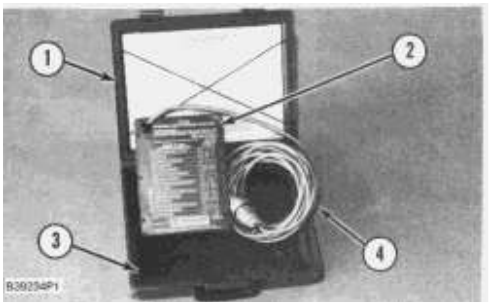


Diagnostic Connector

Testing The Electrical System

Tools Needed		
6V2150	Starting/Charging Analyzer Group	1

NOTE: Make reference to Special Instruction Form No. SEHS7768, and to the instructions inside the cover of the Analyzer Group when using the 6V2150 Starting/Charging Analyzer Group.



6V2150 Starting/Charging Analyzer Group
(1) 6V3072 Case. (2) 6V3112 Base. (3) 6V4174 Packing Set. (4) 4V3178 Cable Assembly.

Use the instructions that follow to hookup and operate the analyzer on this machine.

NOTE: Before you hookup the Analyzer, be sure the batteries are not discharged, see the topic, Battery.

Hookup

1. Connect the Analyzer to the Diagnostic Connector located under the dash.

NOTICE

Remove the ether canister.

---

2. Put the Key Start Switch in the ON position.

3. All accessories must be OFF (lights, heater fan, etc.).

4. The engine must be shut off to start the test.

Operation

Test Step A-Hookup - Make a comparison between the lamps and the lamp normal operation chart next to them. If all lamp indications are the same as shown on the chart, put the Key Start Switch in the OFF position. This should cause the Main Relay And Breaker lamp to come ON. Failure to do so is an indication of a defect in the Relay and/or Breaker. Correct the defect(s), test again and go on to next step. Put the Key Start Switch back in the ON position. If lamp indications are different than shown on the chart, refer to Special Instruction Form No. SEHS7768. Correct defects, test again and then go to next step.

Test Step B-Crank - Crank the engine with the fuel in the "shut off" position. Do not start the engine. Do not use start aid. If all lamp indications are the same as shown on the chart, go to Test Step C. If lamp indications are different than shown, refer to Special Instruction Form No. SEHS7768. Correct defects, test again and go to next step.

Test Step C-Start Aid - Do not start the engine. Push and hold the Start Aid Switch. If all lamp indications are the same as shown on the chart, go to Test Step D. If lamp indications are different than shown, refer to Special Instruction Form No. SEHS7768. Correct defects, test again and go to next step.

Test Step D-Hi Idle - Install ether canister. Start the engine and run at high idle for a minimum of two minutes. If all lamp indications are the same as shown on the chart, turn on all possible electrical accessories; if lamp indications are still the same as shown in the chart, the starting and charging system is within specifications. If the lamp indications are different than shown, refer to Special Instruction

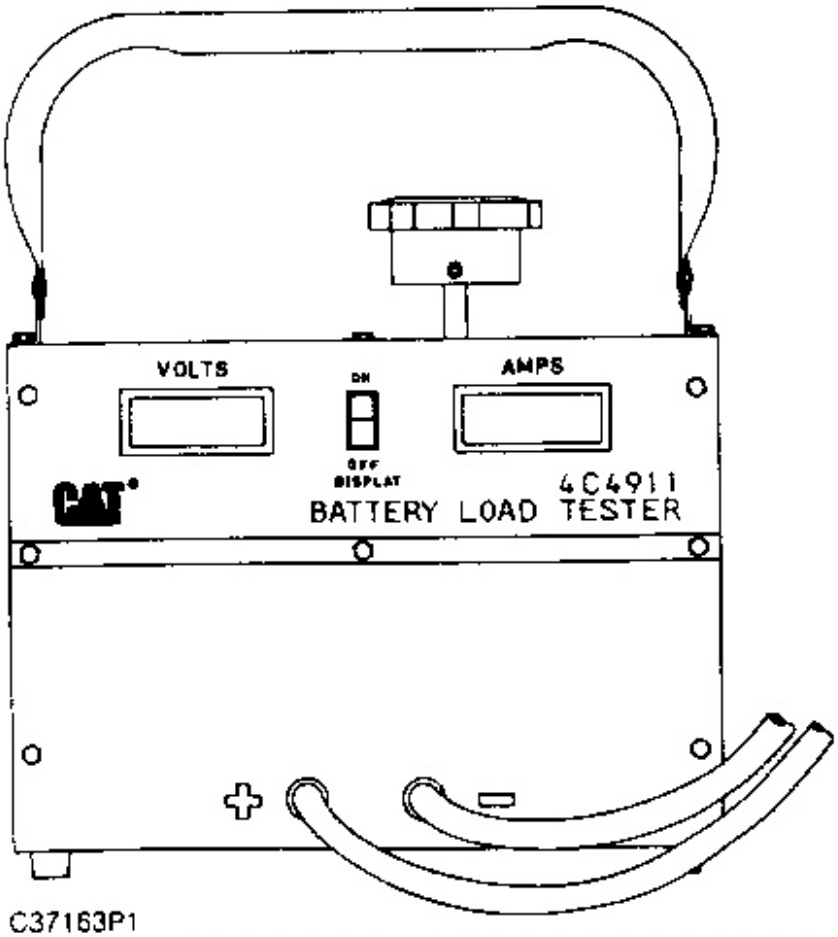
Form No. SEHS7768. Correct defects and test again.

Test Tools For Electrical System

Tools Needed		
4C4911	Battery Load Tester	1
8T0900	AC/DC Clamp-On Ammeter	1
6V7070	Heavy-Duty Digital Multimeter or	1
6V7800	Regular-Duty Digital Multimeter	1

Most of the tests of the electrical system can be done on the engine. The wiring insulation must be in good condition, the wire and cable connections must be clean and tight, and the battery must be fully charged. If the on-engine test shows a defect in a component, remove the component for more testing.

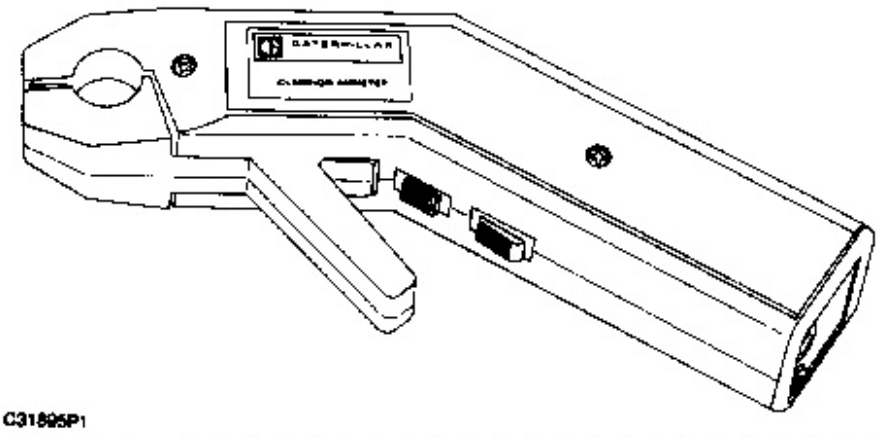
The service manual Testing And Adjusting Electrical Components, Form No. REG00636 has complete specifications and procedures for the components of the starting circuit and the charging circuit.



The 4C4911 Battery Load Tester is a portable unit in a metal case for use under field conditions and high temperatures. It can be used to load test all 6, 8 and 12V batteries. This tester has two heavy-duty load cables that can easily be fastened to the battery terminals. A load adjustment knob on the top permits the current being drawn from the battery to be adjusted to a maximum of 100 amperes. The tester is cooled by an internal fan that is automatically activated when a load is applied.

The tester has a built in LCD digital voltmeter and amperage meter. The digital voltmeter accurately measures the battery voltage at the battery through tracer wires buried inside the load cables. The digital amperage meter accurately displays the current being drawn from the battery under test.

NOTE: Make reference to Operating Manual, Form No. SEHS9249 for more complete information for use of the 4C4911 Battery Load Tester.

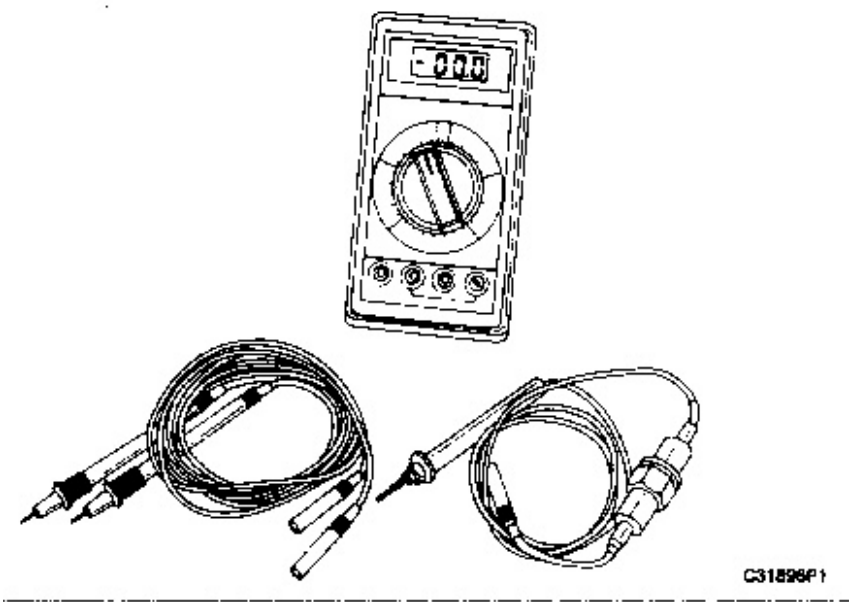


8T0900 AC/DC Clamp-On Ammeter

The 8T0900 AC/DC Clamp-On Ammeter is a completely portable, self-contained instrument that allows electrical current measurements to be made without breaking the circuit or disturbing the insulation on conductors. A digital display is located on the ammeter for reading current directly in a range from 1 to 1200 amperes. If an optional 6V6014 Cable is connected between this ammeter and one of the digital multimeters, current readings of less than 1 ampere can then be read directly from the display of the multimeter.

A lever is used to open the jaws over the conductor [up to a diameter of 19 mm (.75 in)], and the spring loaded jaws are then closed around the conductor for current measurement. A trigger switch that can be locked in the ON or OFF position is used to turn on the ammeter. When the turn-on trigger is released, the last current reading is held on the display for 5 seconds. This allows accurate measurements to be taken in limited access areas where the digital display is not visible to the operator. A zero control is provided for DC operation, and power for the ammeter is supplied by batteries located inside the handle.

NOTE: Make reference to Special Instruction, Form No. SEHS8420 for more complete information for use of the 8T0900 Clamp-On Ammeter.



6V7070 Heavy-Duty Digital Multimeter

The 6V7070 Heavy-Duty Digital Multimeter is a completely portable, hand held instrument with a digital display. This multimeter is built with extra protection against damage in field applications, and is equipped with seven functions and 29 ranges. The 6V7070 Multimeter has an instant ohms indicator that permits continuity checks for fast circuit inspection. It also can be used for troubleshooting small value capacitors.

The 6V7800 Regular-Duty Digital Multimeter (a low cost option to the Heavy-Duty Multimeter) is also available; however, the 6V7800 Multimeter does not have the 10A range or the instant ohms feature of the 6V7070 Multimeter.

NOTE: Make reference to Special Instruction, Form No. SEHS7734 for more complete information for use of the 6V7070 and 6V7800 Multimeters

Battery

WARNING

Never disconnect any charging unit circuit or battery circuit cable from battery when the charging unit is operated. A spark can cause an explosion from the flammable vapor mixture of hydrogen and oxygen that is released from the electrolyte through the battery outlets. Injury to personnel can be the result.

The battery circuit is an electrical load on the charging unit. The load is variable because of the condition of the charge in the battery. Damage to the charging unit can result if the connections (either positive or negative) between the battery and charging unit are broken while the charging unit is in operation. This is because the battery load is lost and there is an increase in charging voltage. High voltage can damage, not only the charging unit, but also the regulator and other electrical components.

Use the 4C4911 Battery Load Tester, the 8T0900 Clamp-On Ammeter and the 6V7070 Multimeter to load test a battery that does not hold a charge when in use. See Special Instruction, Form No. SEHS8268 for the correct procedure and specifications to use.

Charging System

The condition of charge in the battery at each regular inspection will show if the charging system operates correctly. An adjustment is necessary when the battery is constantly in a low condition of charge or a large amount of water is needed (more than one ounce of water per cell per week or per every 100 service hours).

When it is possible, make a test of the charging unit and voltage regulator on the engine, and use wiring and components that are a permanent part of the system. Off engine (bench) testing will give a test of the charging unit and voltage regulator operation. This testing will give an indication of needed repair. After repairs are made, again make a test to give proof that the units are repaired to their original condition of operation.

Before the start of on engine testing, the charging system and battery must be checked as shown in the Steps that follow:

1. Battery must be at least 75 percent (1.225 Sp Gr) fully charged and held tightly in place. The battery holder must not put too much stress on the battery.

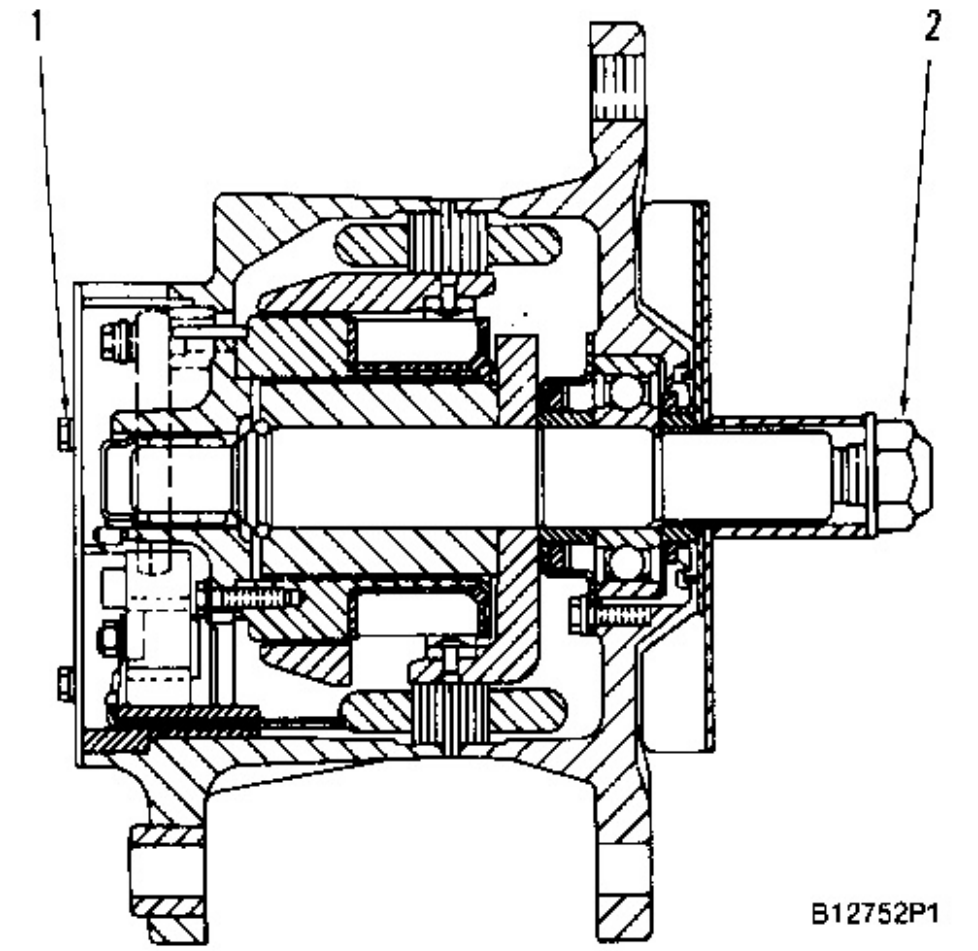
2. Cables between the battery, starter and engine ground must be the correct size. Wires and cables must be free of corrosion and have cable support clamps to prevent stress on battery connections (terminals).

3. Leads, junctions, switches, and panel instruments that have direct relation to the charging circuit must give correct circuit control.

4. Inspect the drive components for the charging unit to be sure they are free of grease and oil and have the ability to operate the charging unit.

Alternator Regulator Adjustment

When an alternator is charging the battery too much or not enough, the charging rate of the alternator should be checked. Make reference to the Specifications module to find all testing specifications for the alternators and regulators.

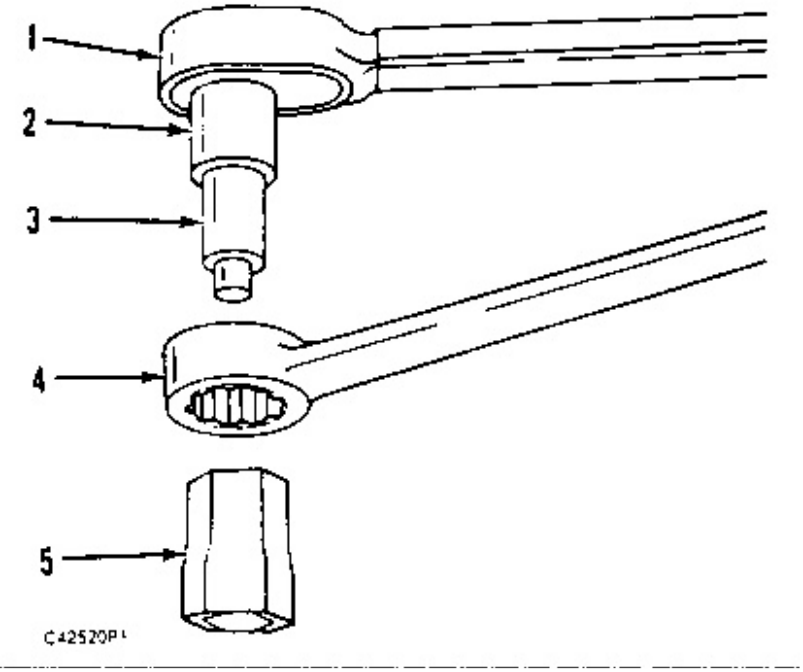


Alternator
(1) Ground terminal. (2) Pulley nut.

No adjustment can be made to change the rate of charge on the alternator regulators. If rate of change is not correct, a replacement of the regulator is necessary.

Alternator Pulley Nut Tightening

Tighten nut that holds the pulley to a torque of 100 ± 10 N·m (75 ± 5 lb ft) with the tools shown.



Tools To Tighten Alternator Pulley Nut
(1) 8T9293 Torque Wrench. (2) 8S1588 Adapter (1/2 inch female to 3/8 inch male). (3) 2P8267 Socket Assembly. (4) 8H8517 Combination Wrench (1-1/8 inch). (5) 8T5314 Socket.

Starting System

Use the multimeter in the DCV range to find starting system components which do not function.

Move the start control switch to activate the starter solenoid. Starter solenoid operation can be heard as the pinion of the starter motor is engaged with the ring gear on the engine flywheel.

If the solenoid for the starter motor will not operate, it is possible that the current from the battery did not get to the solenoid. Fasten one lead of the multimeter to the connection (terminal) for the battery cable on the solenoid. Put the other lead to a good ground. A zero reading is an indication that there is a broken circuit from the battery. More testing is necessary when there is a voltage reading on the multimeter.

The solenoid operation also closes the electric circuit to the motor. Connect one lead of the multimeter to the solenoid connection (terminal) that is fastened to the motor. Put the other lead to a good ground. Activate the starter solenoid and look at the multimeter. A reading of battery voltage shows the problem is in the motor. The motor must be removed for further testing. A zero reading on the multimeter shows that the solenoid contacts do not close. This is an indication of the need for repair to the solenoid or an adjustment to be made to the starter pinion clearance.

Make a test with one multimeter lead fastened to the connection (terminal) for the small wire at the solenoid and the other lead to the ground. Look at the multimeter and activate the starter solenoid. A voltage reading shows that the problem is in the solenoid. A zero reading is an indication that the problem is in the start switch or the wires for the start switch.

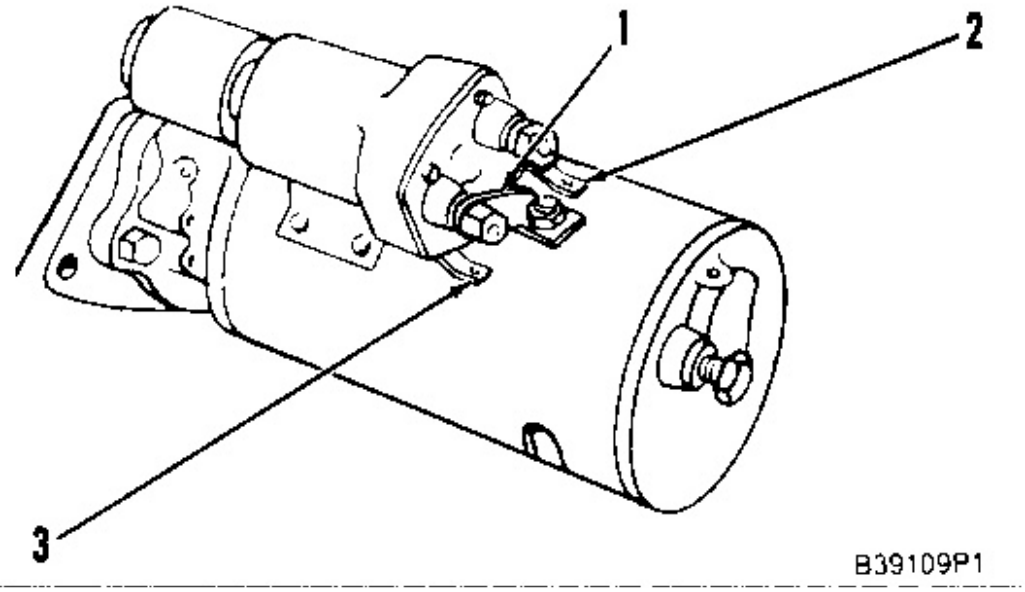
Fasten one multimeter lead to the start switch at the connection (terminal) for the wire from the battery. Fasten the other lead to a good ground. A zero reading indicates a broken circuit from the battery. Make a check of the circuit breaker and wiring. If there is a voltage reading, the problem is in the start switch or in the wires for the start switch.

A starter motor that operates too slow can have an overload because of too much friction in the engine

being started. Slow operation of the starter motor can also be caused by a short circuit, loose connections and/or dirt in the motor.

Pinion Clearance Adjustment (8C3593, 8C3644 and 8C3649)

When the solenoid is installed, make an adjustment of the pinion clearance. The adjustment can be made with the starter motor removed.



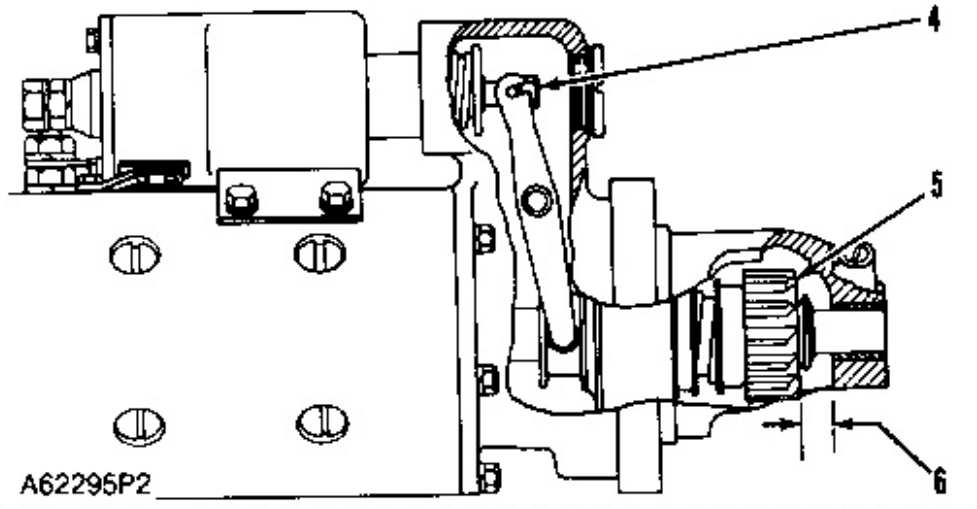
Connection For Checking Pinion Clearance
(1) Connector from Motor terminal on solenoid to motor. (2) SW terminal (3) Ground terminal.

1. With the solenoid installed on the starter motor, remove connector (1).

2. Connect a battery, of the same voltage as the solenoid, to the terminal (2), marked SW.

3. Connect the other side of the battery to ground terminal (3).

4. Connect for a moment a wire from the solenoid connection (terminal) marked Motor to the ground connection (terminal). The pinion will shift to crank position and will stay there until the battery is disconnected.



Pinion Clearance Adjustment
(4) Shaft nut. (5) Pinion. (6) Pinion clearance.

5. Push the pinion toward the commutator end to remove free movement.

6. Pinion clearance (6) must be 8.3 to 9.9 mm (.33 to .39 in).

7. To adjust pinion clearance, remove plug and turn nut (4).

8. After the adjustment is completed, install the plug over adjustment nut (4) and install connector (1) between the Motor terminal on the solenoid and the starter motor.

Pinion Clearance Adjustment (6T0646)

There are two adjustments on this type motor. They are end play for the armature and pinion clearance.

Endplay For The Armature

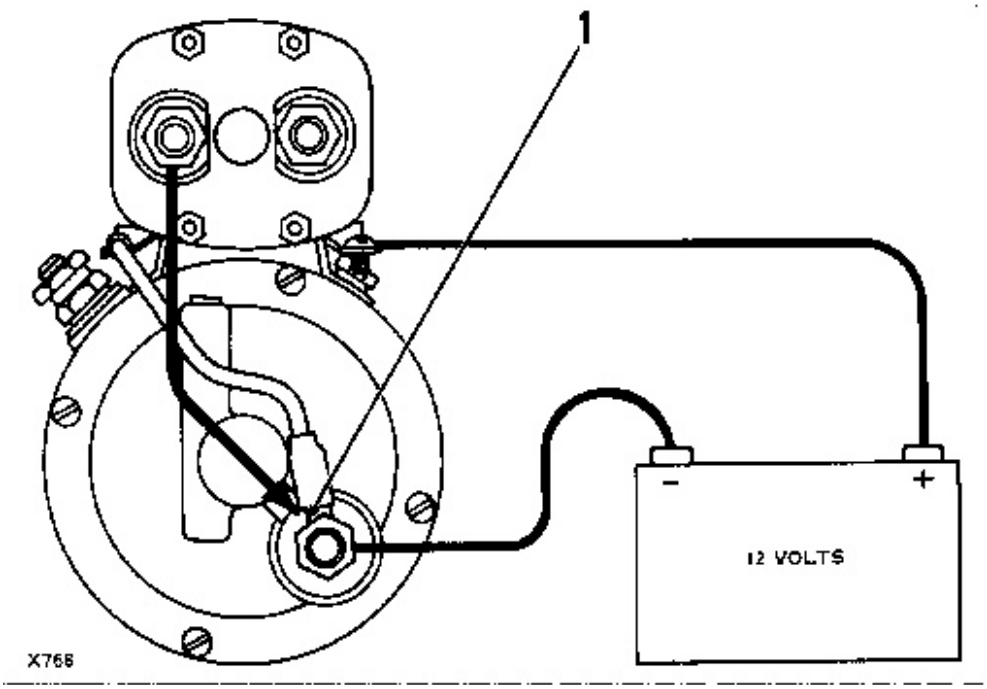
The correct endplay for the armature is 0.13 to 0.76 mm (.005 to .030 in). The adjustment is made by adding or removing thrust washers on the commutator end of the armature shaft.

Pinion Clearance Adjustment

1. To adjust the pinion distance, connect the 24V solenoid to a 12 volt battery (12V solenoid to a 6V battery) as shown. For a short moment, connect a wire from the "motor" stud of the solenoid to the stud at (1) in the commutator end. This moves the solenoid and drive into the cranking position.

Disconnect the wire.

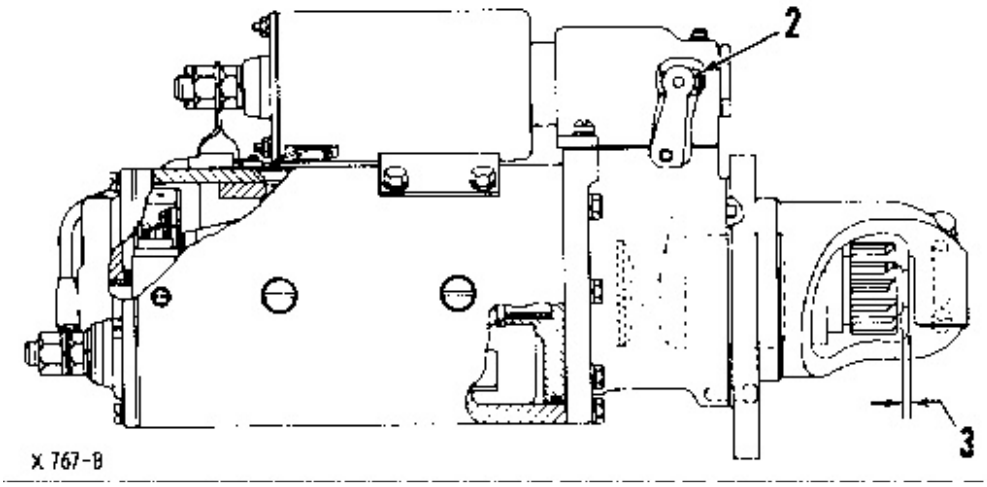
NOTE: The drive is in the cranking position until the battery is disconnected.



Connections For Adjustment Of The Pinion Clearance
(1) Stud.

2. Push the drive toward the commutator end of the motor to eliminate any slack movement in the

linkage and measure the distance between the outside edge of the drive sleeve and the thrust washer. The distance (3) must be 0.51 to 1.27 mm (.020 to .050 in).



Pinion Clearance Adjustment
(2) Adjusting nut. (3) Distance.

3. Remove the plug. Turn the adjusting nut (2) in or out as necessary to get this distance.

4. Install the plug.

Sun Jun 27 12:52:05 UTC-0300 2010