CATERPILLAR®

Service Information System

Shutdown SIS

Previous Screen

Jakes 1,3,5 Top Dead Compress
2,4,6

Product: NO EQUIPMENT SELECTED
Model: NO EQUIPMENT SELECTED
Configuration: NO EQUIPMENT SELECTED

Testing and Adjusting
3406C DIESEL TRUCK ENGINE
Media Number -SENR6547-01 **Publication Date -24/02/1997** **Date Updated -12/10/2001**

intake .015 (.38) mm
exhaust .030 (.76) mm

Testing and Adjusting

Introduction

When the words "use again" are in the description, the specification given can be used to determine if a part can be used again. If the part is equal to or within the specification given, use the part again.

When the word "permissible" is in the description, the specification given is the "maximum or minimum" tolerance permitted before adjustment, repair and/or new parts are needed.

A comparison can be made between the measurements of a worn part and the specifications of a new part to find the amount of wear. A part that is worn can be safe to use if an estimate of the remainder of its service life is good. If a short service life is expected, replace the part.

Reference: See 3406C Diesel Truck Engine, SENR6546, for Specifications.

NOTE: Additional troubleshooting information can be found in the Troubleshooting Guide, SENR6521.

Jakes 47 FT(S)
NOT 100 FT(S)

BrakeSaver Troubleshooting

There are two operation checks that are fast and need no special equipment. One check is the Pull-Down RPM Check to see if the BrakeSaver can give full braking force. The other check is the Klunk Check to see if the valve spool in the BrakeSaver control valve has free movement. These two checks give an approximate indication that the BrakeSaver has the correct operation.

Pull-Down RPM Check

NOTE: The engine must give rated horsepower for this test to have accuracy.

1. Actuate the brakes, put the transmission in NEUTRAL and operate the engine at high idle rpm (accelerator pedal all the way down).

2. Make a record of the engine rpm.

3. Put the BrakeSaver control to the full ON position.

4. Make a record of the engine rpm with the BrakeSaver full on.

5. The engine rpm with the BrakeSaver full on must be 150 ± 25 rpm less than the engine rpm with the BrakeSaver off.

NOTE: If the difference in rpm is less than 125 rpm, the BrakeSaver is not giving full braking force.

NOTE: If the difference in rpm is more than 175 rpm, check the air pressure to the BrakeSaver control valve. The air pressure must not be more than 345 kPa (50 psi).

NOTICE

Do not run the engine at high idle rpm with the BrakeSaver ON for more than 15 seconds at a time. Let the engine run a low idle with the BrakeSaver off for five minutes to keep from getting the engine cooling system too hot.

Klunk Check (check for free movement of the valve spool)

1. Run the engine until the truck air system is at its maximum pressure and then stop the engine.

2. Put the BrakeSaver in the full ON position before the air pressure in the truck air system gets below 480 kPa (70 psi).

3. Put the BrakeSaver in the OFF position. A noise ("klunk") must be heard at the BrakeSaver control valve as the valve spool hits the cover at the air inlet end of the control valve.

4. If the noise is not heard at the BrakeSaver control valve, remove and disassemble the control valve. Inspect the valve for:

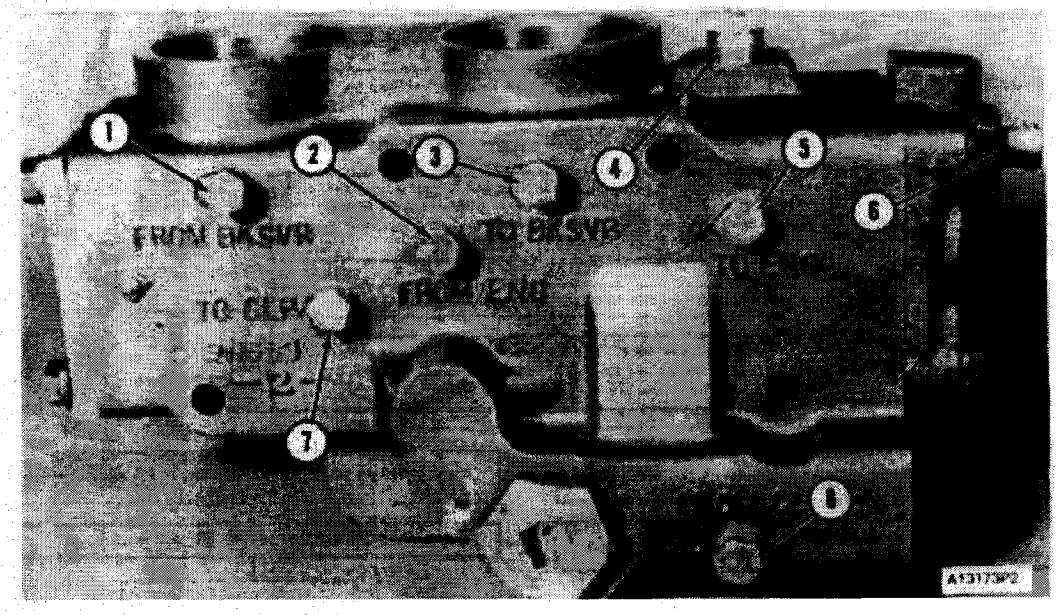
* A damaged valve body.
* Damaged or worn springs in the valve spool.
* Damaged or worn valve spool.
* Damaged or worn O-ring seals or diaphragm in the control valve.
* Closed holes (small holes to feel pressure) in the side of the valve spool.

For specific problems, make reference to the BrakeSaver Troubleshooting Problem List.

BrakeSaver Troubleshooting Problem List

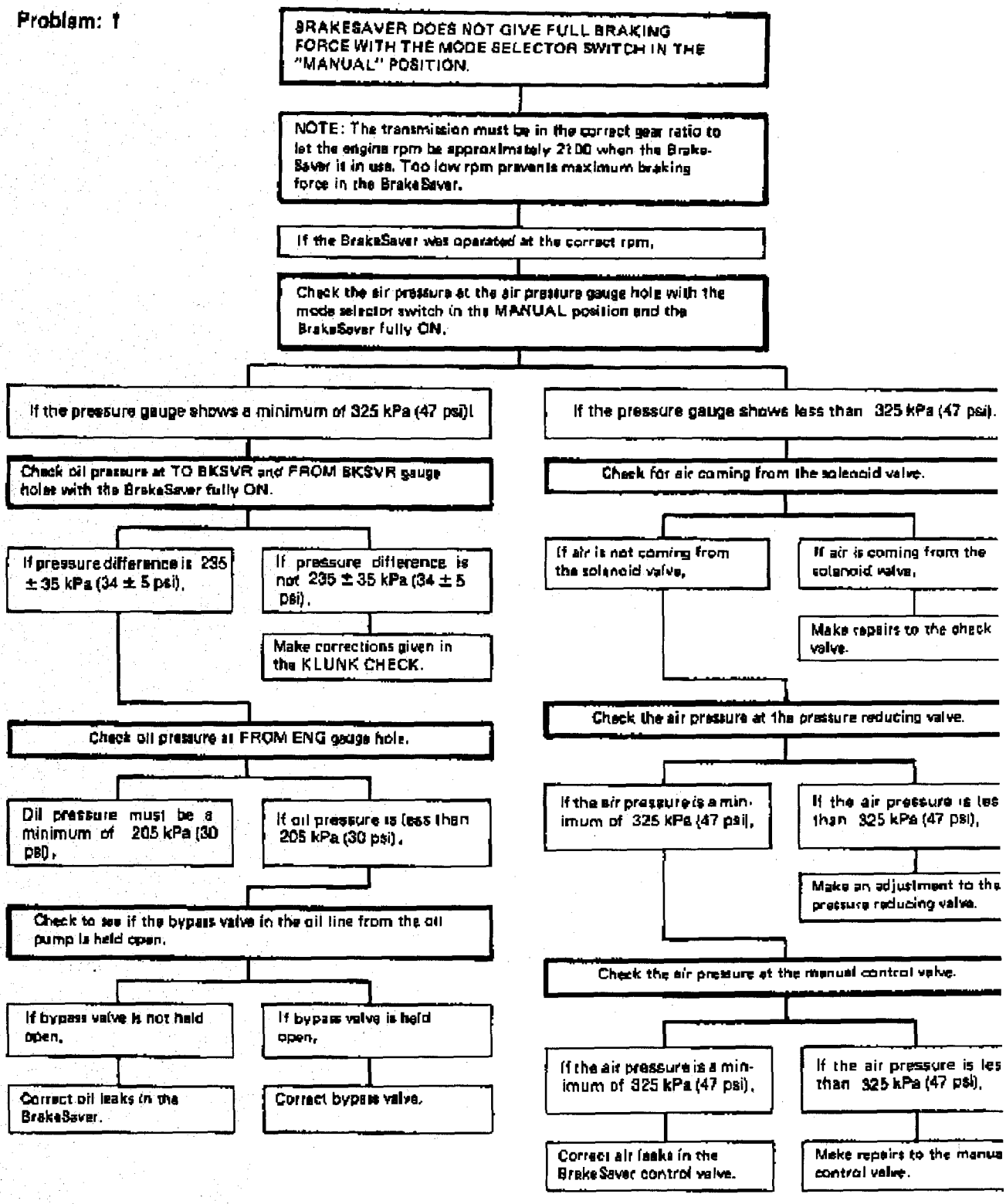
1. BrakeSaver Does Not Give Full Braking Force With The Selector Switch In The MANUAL Position.

2. BrakeSaver Does Not Give Full Braking Force With The Selector Switch In The AUTOMATIC-MANUAL Position.
3. BrakeSaver Oil Temperature Is Too High.
4. BrakeSaver Does Not Turn OFF Or Become Empty.
5. Oil Leakage From The Flywheel Housing.
6. Oil Leakage From The Clutch Housing Or Transmission.



Indicator Holes For Troubleshooting
(1) Oil pressure from the BrakeSaver. (2) Oil pressure from the engine. (3) Oil pressure to the BrakeSaver. (4) Test point for BrakeSaver oil temperature. (5) Oil pressure to the engine. (6) Air pressure hole from the control valve. (7) Oil pressure to the cooler. (8) Oil pressure from the cooler.

Problem: 1



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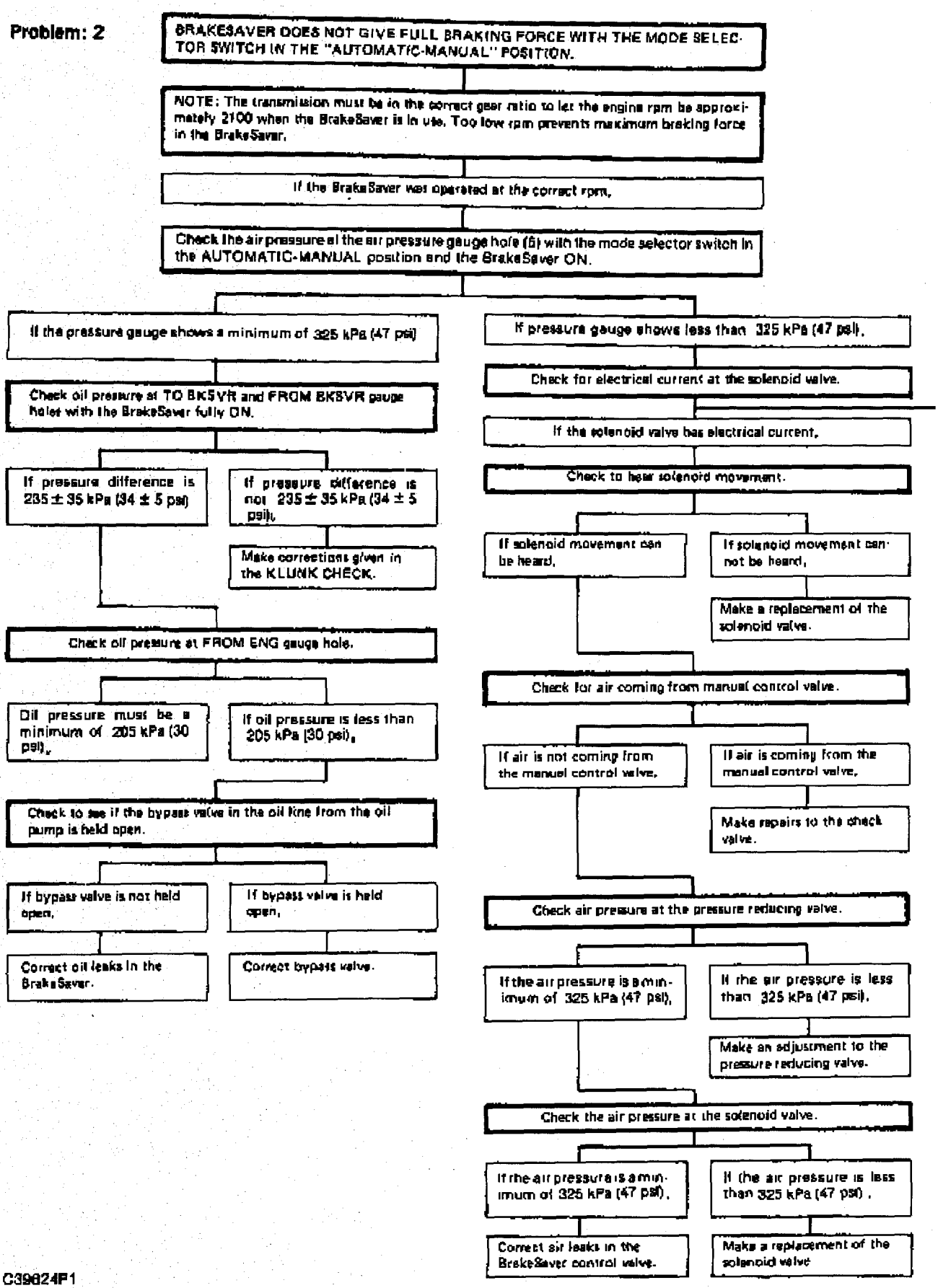
Problem: 2



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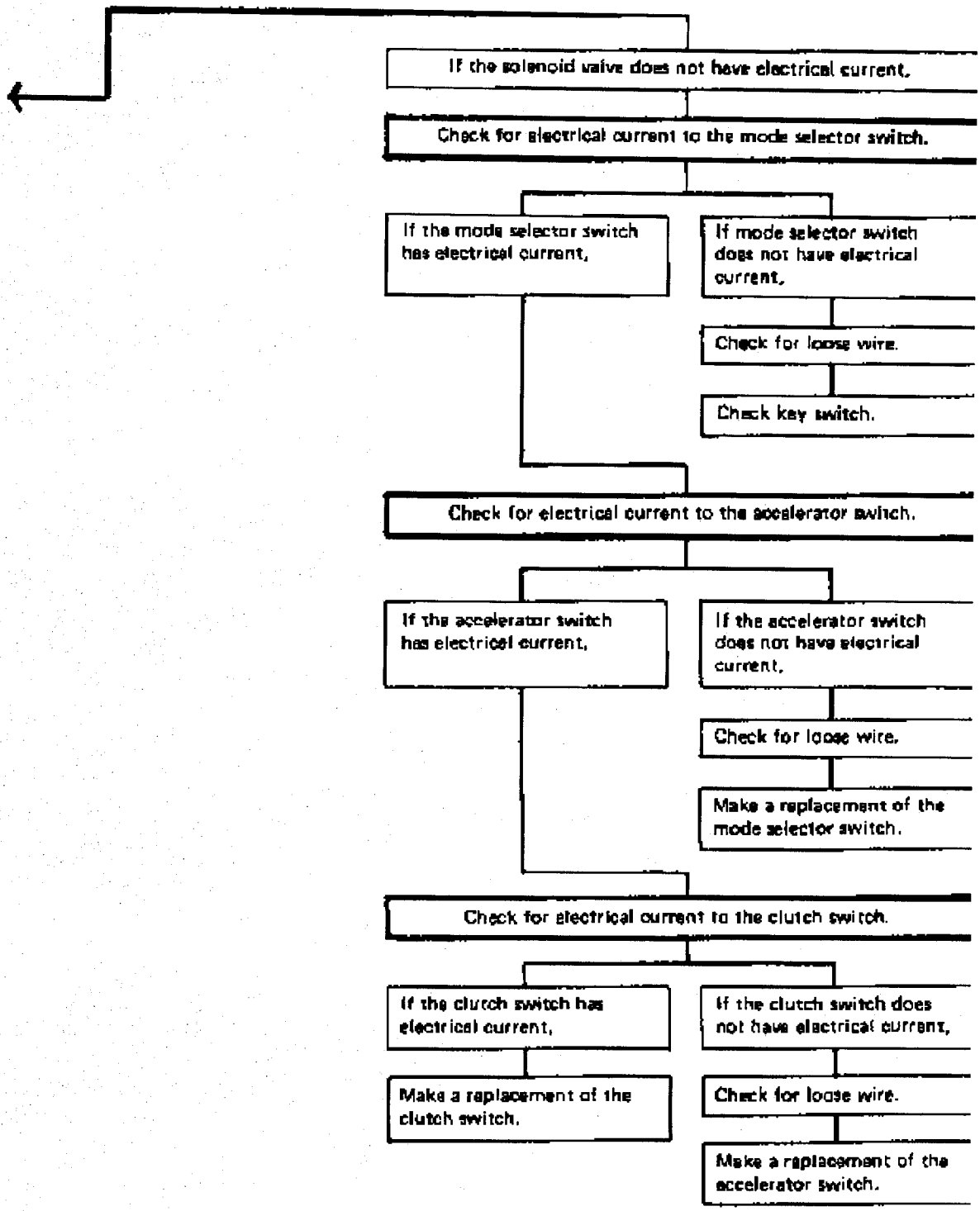
If the solenoid valve does not have electrical current,
Check for electrical current to the mode selector switch.
If the mode selector switch has electrical current,
If mode selector switch does not have electrical current,
Check for loose wire.
Check key switch.
Check for electrical current to the accelerator switch.
If the accelerator switch has electrical current,
If the accelerator switch does not have electrical current,
Check for loose wire.
Make a replacement of the mode selector switch.
Check for electrical current to the clutch switch.
If the clutch switch has electrical current,
If the clutch switch does not have electrical current,
Make a replacement of the clutch switch.
Check for loose wire.
Make a replacement of the accelerator switch.

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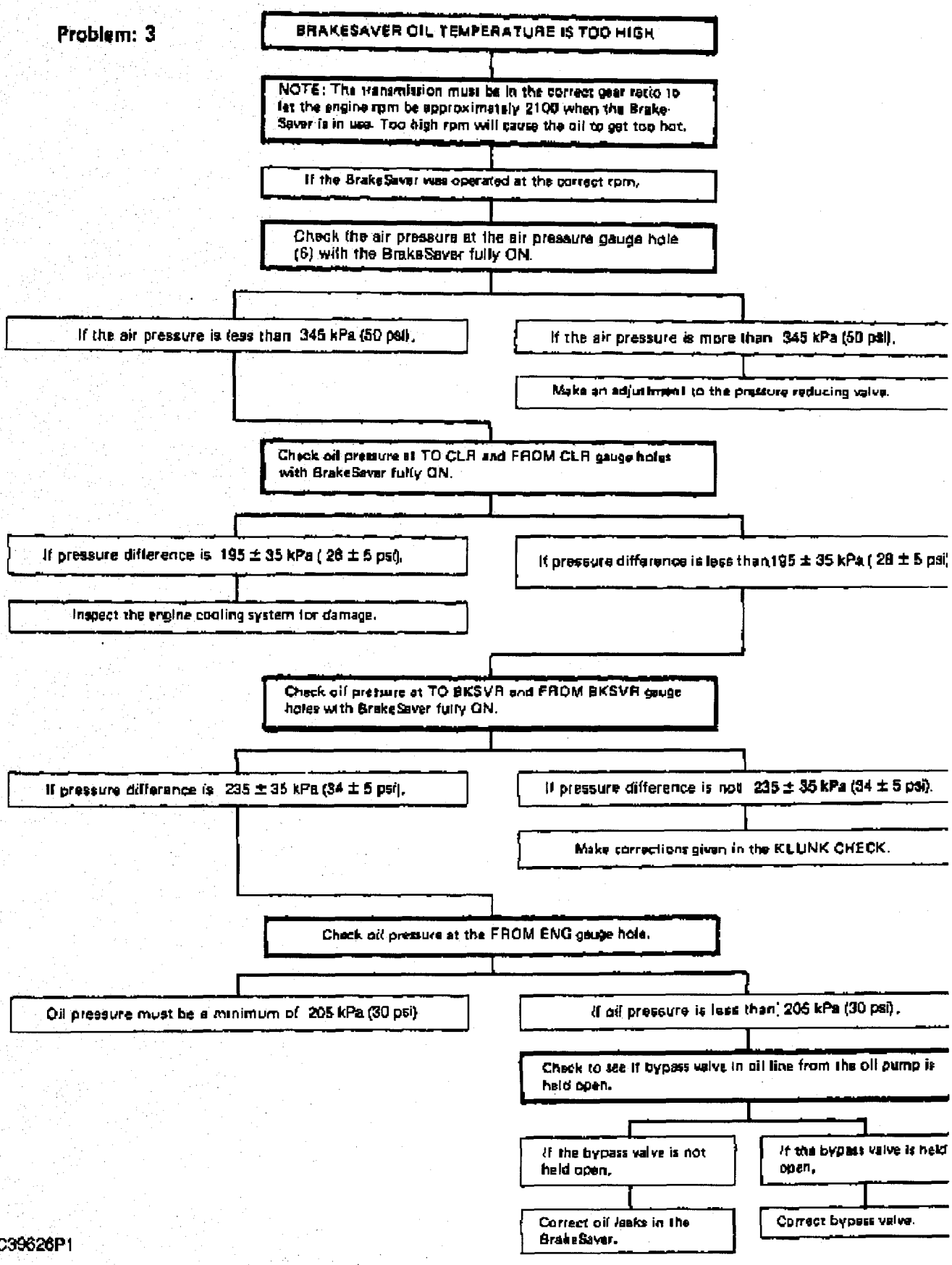
Problem: 3



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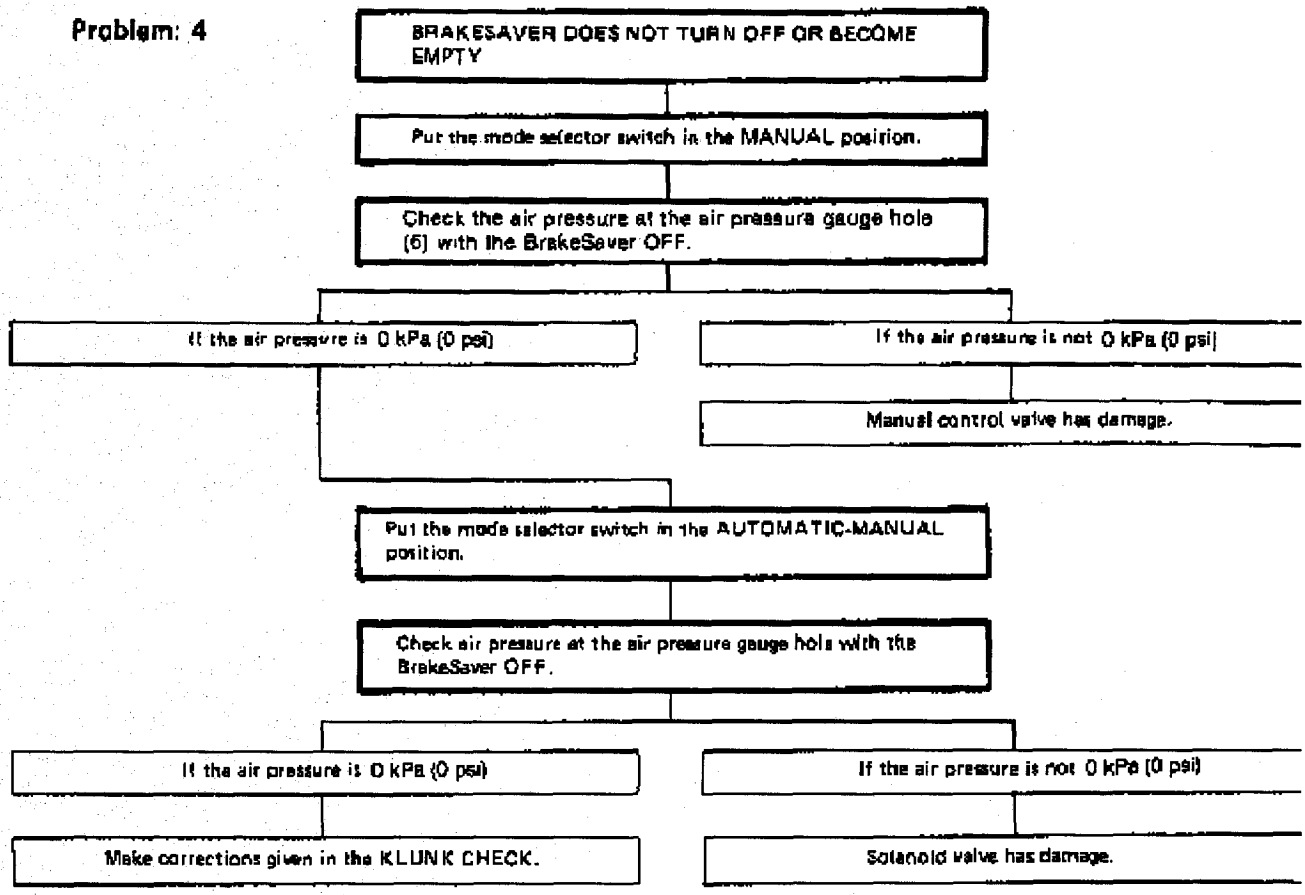
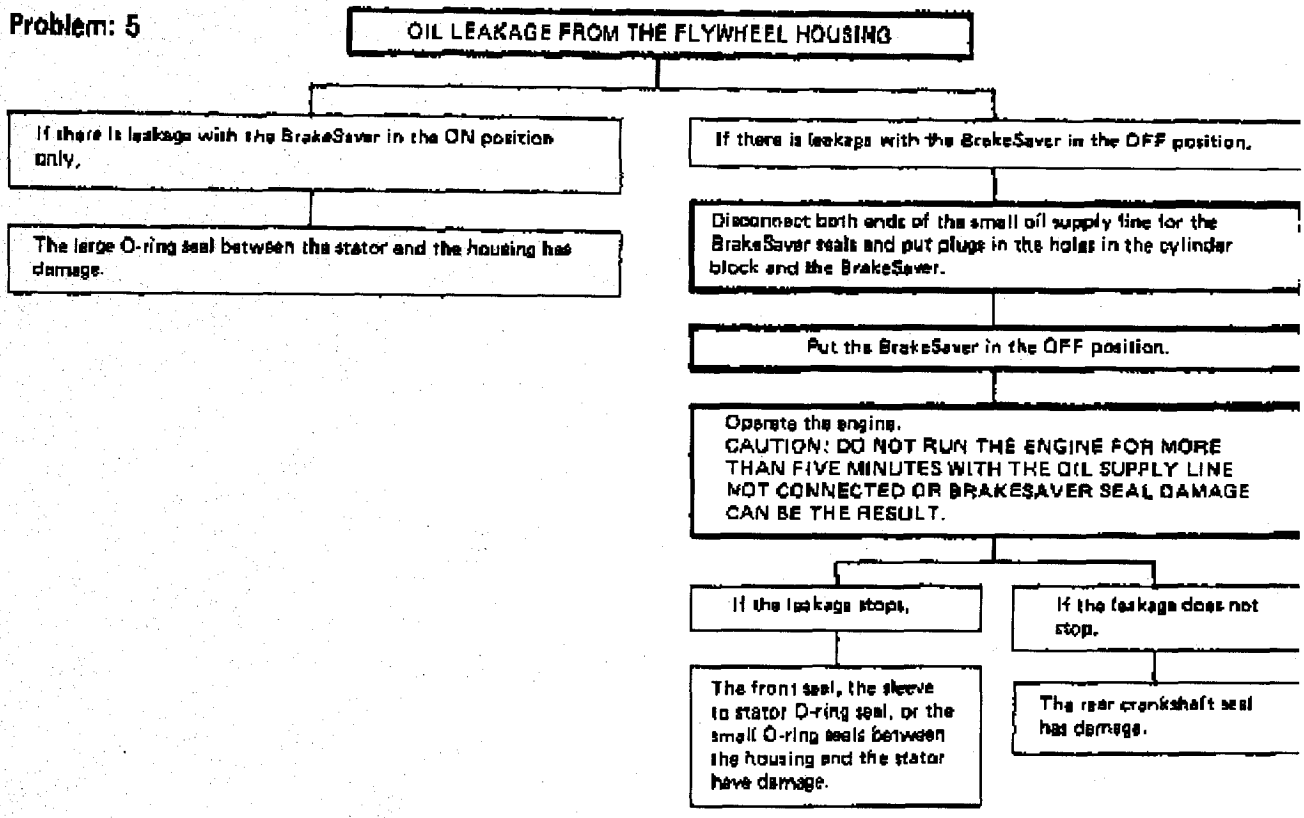
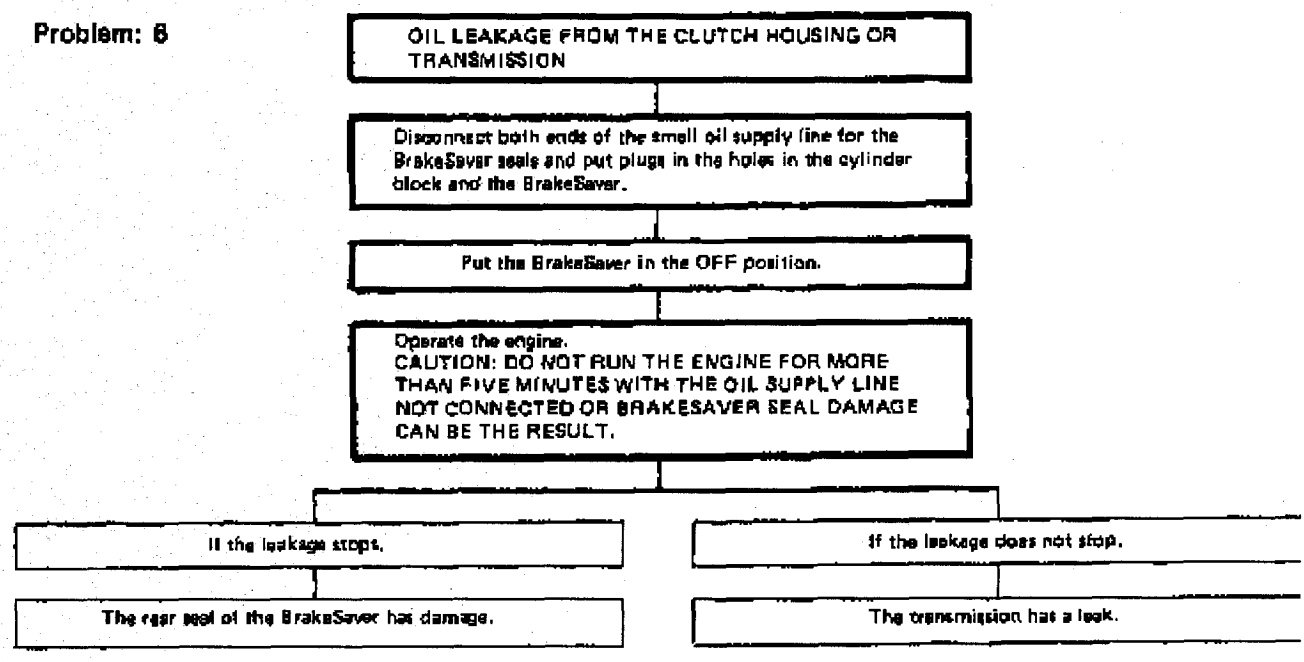

Problem: 4
BRAKESAVER DOES NOT TURN OFF OR BECOME EMPTY
Put the mode selector switch in the MANUAL position.
Check the air pressure at the air pressure gauge hole (6) with the BrakeSaver OFF.
If the air pressure is 0 kPa (0 psi)
If the air pressure is not 0 kPa (0 psi)
Manual control valve has damage.
Put the mode selector switch in the AUTOMATIC-MANUAL position.
Check air pressure at the air pressure gauge hole with the BrakeSaver OFF.
If the air pressure is 0 kPa (0 psi)
If the air pressure is not 0 kPa (0 psi)
Make corrections given in the KLUNK CHECK.
Solenoid valve has damage.

C39827P1

Problem: 5



Problem: 6



C3962

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 fuel injection nozzle, but it can also be caused by one or more of the reasons that follow:

* Not enough air for good combustion.
* An overload at high altitude.
* Oil leakage into combustion chamber.
* Not enough compression.
* Fuel injection timing retarded.

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 defective bend.

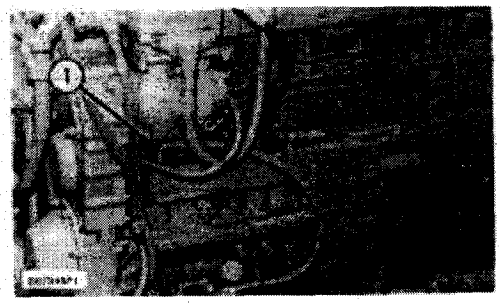
3. Install a new fuel filter. Clean the primary fuel filter.

4. Remove any air that may be in the fuel system. Use the fuel priming pump to move fuel through low pressure part of the system. Fuel with air will return to the tank through the fuel return line.

To remove air from the fuel injection lines, loosen the fuel line nuts at the through the head adapter nozzles 1/2 turn. Crank engine with the starting motor until fuel without air comes from the fuel line connections. Tighten the fuel line nuts.

NOTE: The fuel priming pump will not give enough pressure to push fuel through the orifice reverse flow check valves in the fuel injection pumps.

Fuel Transfer Pump



Fuel Lines
(1) Fuel inlet.

With the engine operating at full load speed, the fuel transfer pump moves fuel through the secondary filter and the fuel injection pump housing at approximately 240 kPa (35 psi).

To check the fuel transfer pump pressure, disconnect the fuel line (from the filter) at the fuel injection pump housing inlet (1). Install a tee at inlet (1) and connect the fuel line to the tee. Connect a pressure indicator to the tee and start the engine.

Minimum fuel pressures must be 70 kPa (10 psi) at low idle and 170 kPa (25 psi) at full load speed (and engine under full load).

If the fuel pressure is not above the minimum specifications, stop the engine. Make a replacement of the primary and secondary fuel filters and check to make sure the fuel lines and hoses are not plugged or damaged.

Start the engine and again check the fuel pressure. If the fuel pressure is not above the minimum specification, a repair or replacement of the fuel transfer pump is needed.

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 fuel injection nozzle for that cylinder.

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

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

1. Steel wire brushing of nozzle tip.
2. Orifice wear.
3. Dirty nozzle screen.

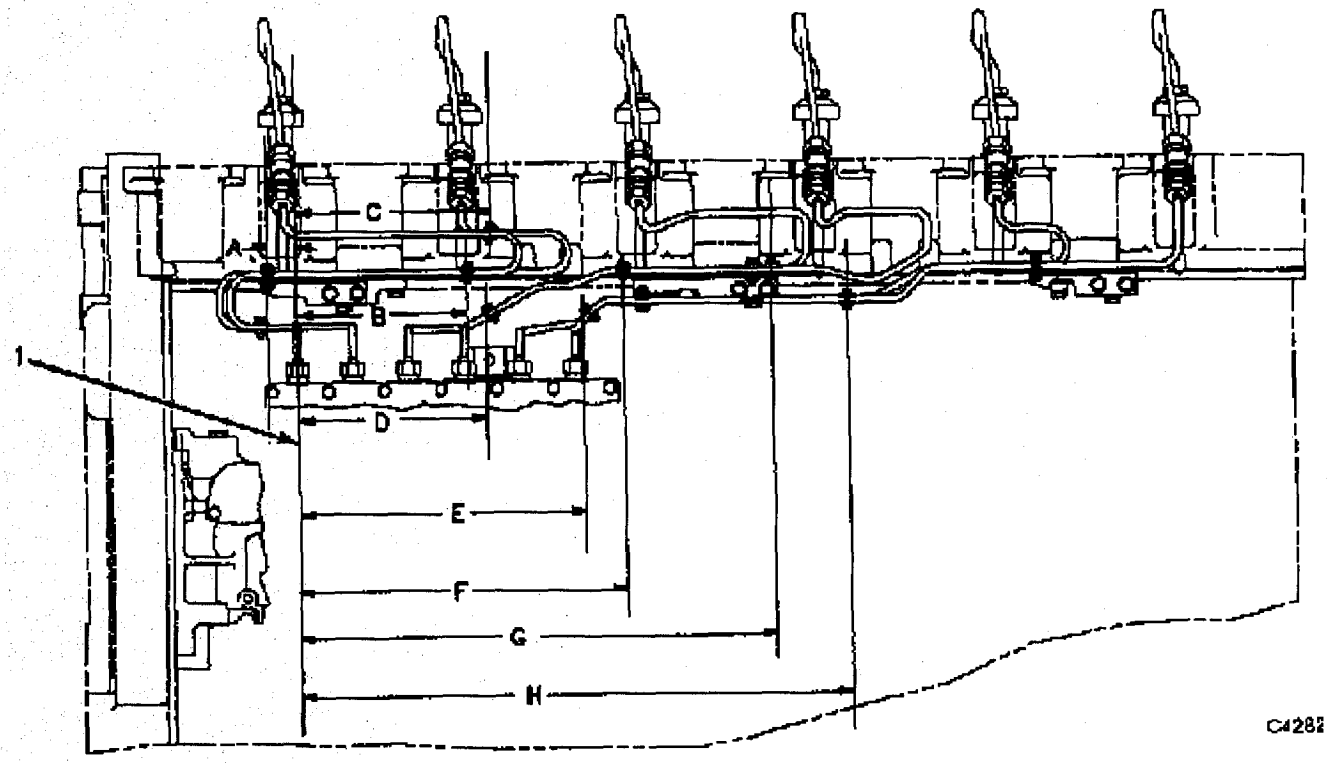
NOTICE

Do not test nozzles unless you have the correct service tools.

Fuel Injector Testing

Testing of the injectors must be done off the engine. Use 5P4150 Nozzle Testing Group. For use of the 5P4150 Nozzle Testing Group, refer to Special Instructions, SEHS7292.

Fuel Injection Lines



Fuel Injection Line Without Support Bracket
(1) A vertical line through the number one injection pump.

Clamp location dimensions are in reference to a vertical line through the number one injection pump.

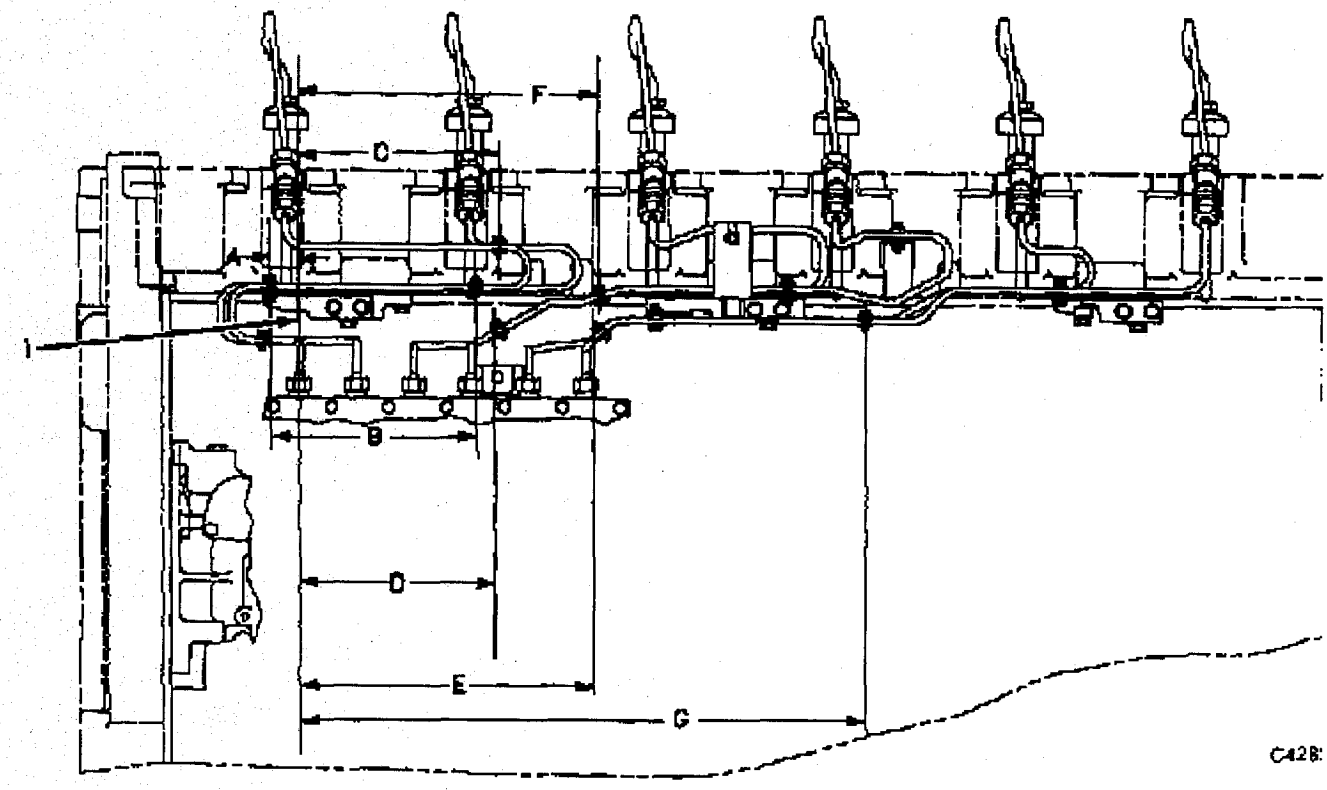
Location	Dimension
A	35 ± 3 mm (1.38 ± .12 in)
B	165 ± 13 mm (6.50 ± .51 in)
C	187 ± 1 mm (7.36 ± .04 in)
D	187 ± 3 mm (7.36 ± .12 in)
E	282 ± 3 mm (11.10 ± .12 in)
F	314 ± 13 mm (12.36 ± .51 in)
G	457 ± 3 mm (17.99 ± .12 in)
H	529 ± 3 mm (20.83 ± .12 in)

Fuel from the fuel injection pumps goes to the fuel injection nozzles through the fuel injection lines.

When fuel injection lines are disconnected or removed, always put caps or plugs on the ends to keep dirt out of the lines. When fuel injection lines are installed, be sure all clamps and dampers are installed in their original location.

⚠ WARNING

Fuel injection lines which are bent, damaged or rubbing can leak and cause a fire. Replace any lines which have damage or leaks that can not be corrected when tightened to the correct torque.



Fuel Injections Lines With Support Bracket
(1) A vertical line through the number one injection pump.

The nuts that hold a fuel injection line to an injection pump must be tightened to the correct torque. If the nut is loose, fuel will leak from the connection. If the nut is tightened too tight, the inside diameter of the line will become smaller and cause a restriction to the flow of fuel in the line. Use a torque wrench and a 5P0144 Fuel Line Socket to tighten the fuel injection line nuts to 42 ± 7 N·m (31 ± 5 lb ft).

⚠ WARNING

Be sure the fuel injection line clamps are installed in the correct location. Incorrectly installed clamps may allow the fuel injection lines to vibrate and become damaged. The damaged lines may leak and cause a fire.

Location	Dimension
A	35 ± 3 mm (1.38 ± .12 in)
B	165 ± 13 mm (6.50 ± .51 in)
C	187 ± 1 mm (7.36 ± .04 in)
D	187 ± 3 mm (7.36 ± .12 in)
E	282 ± 3 mm (11.10 ± .12 in)
F	283 ± 3 mm (11.14 ± .12 in)
G	529 ± 3 mm (20.83 ± .12 in)

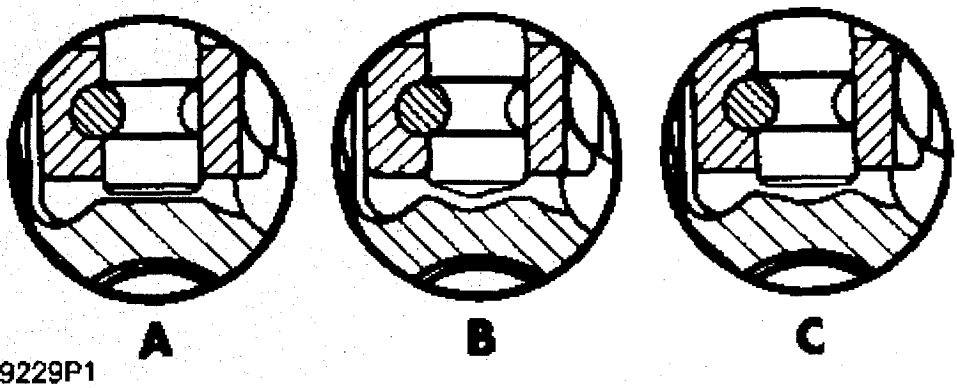
Tighten metal-to metal clamps to a torque of ... 2.3 N·m (20 lb in)

NOTE: The 6V4980 Torque Screwdriver Tool Group is available for applying the correct torque.

Checking The Plunger And Lifter Of An Injection Pump

NOTE: There are no different size spacers available to adjust the timing dimension of the fuel injection pumps. If the pump plunger or the lifter is worn, they must be replaced. Because there is no adjustment to the timing dimension possible, there is No Off Engine Lifter Setting Procedure.

When there is too much wear on the fuel injection pump plunger, the lifter 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 the lifters that have wear.



Wear Between Lifter and Plunger
Fig. A. Illustrates the contact surfaces of a new pump plunger and a new lifter. In Fig. B the pump plunger and lifter have worn considerably. Fig. C shows how the flat end of a new plunger makes poor contact with a worn lifter, resulting in rapid wear to both parts.

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)	77.423 ± 0.013 mm (3.0481 ± .0005 in)
Minimum length (worn)	77.397 mm (3.0471 in)

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.

Removal And Installation Of Fuel Injection Pumps

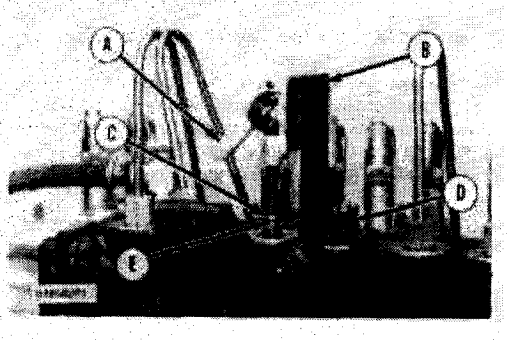
Tools Needed		
9U5219	Engine Tool Group.	1
8T9198	Bracket Assembly*	1
1U5426	Compressor Assembly*	1
6V4186	Timing Pin*	1
8T5287	Wrench	1
8S2244	Extractor	1
6V7050	Compressor	1

* Part of 9U5219 Engine Tool Group

This procedure can be done with the fuel injection pump housing on or off the engine.

Before the 6V7050 Compressor Group is used for the first time, or if the group has been disassembled, make the following adjustment:

1. An injection pump that is to be used for this adjustment (or one that is to be removed or installed) must have another injection pump installed next to it. The second injection pump serves as the compressor mounting stud. If there are not two injection pumps next to each other, install two injection pumps without the lifter springs. See Installation Of Fuel Injection Pumps for the correct alignment of the pump at assembly.



Adjustment of 6V7050 Compressor Group
(A) 6V7015 Clamp. (B) Bracket assembly. (C) 4B2046 Nut. (D) 8T0937 Nut. (E) 2N3476 Screw.

2. Put bracket assembly (B) over one of the pump bonnets.

3. Put the clamp ram on the center of the other injection pump bonnet with 2N3476 Screw (E) in contact with the fuel line seat.

NOTE: The 6V7015 Clamp (A) should not be locked down.

4. Install and tighten 8T0937 Nut (D).

5. Adjust screw in or out until the top of bracket assembly (B) just starts to move when the clamp ram is locked down.

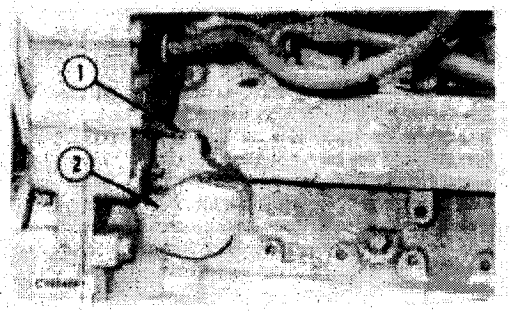
6. Tighten 4B2046 Nut (C) to hold 2N3476 Screw (E) in position.

Removal Of Fuel Injection Pumps

NOTICE

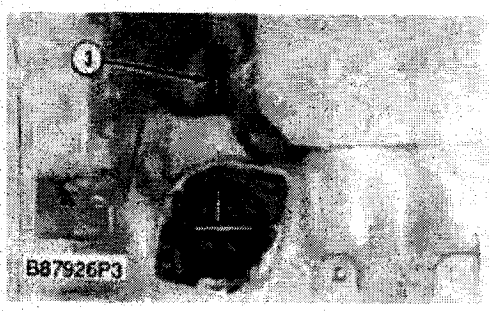
Before any parts are removed from the fuel injection pump housing, thoroughly clean all dirt from the housing. Dirt that gets inside the pump housing will cause much damage.

NOTE: The fuel rack must be in the zero (center) position before the fuel injection pumps can be removed or installed. Follow Steps 1 through 5.



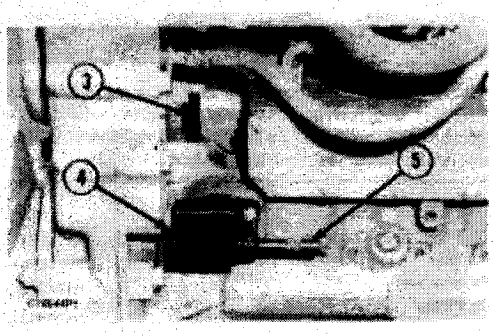
Fuel Injection Pump Housing
(1) Plug (rack centering pin). (2) Cover (rack position indicator).

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



Fuel Rack Against Timing Pin in the Zero Position
(3) 6V4186 Timing Pin.

2. Install the 6V4186 Timing Pin (3) in the top of the fuel injection pump housing. Make sure 6V4186 Timing pin (3) engages in the slot of the fuel rack as shown.

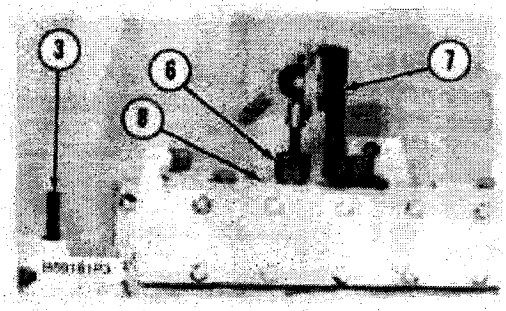


Holding Fuel Rack in Zero Position
(3) 6V4186 Timing Pin. (4) 8T9198 Bracket Assembly. (5) 1U5426 Compressor Assembly.

3. Install 8T9198 Bracket Assembly (4) on the fuel injection pump housing. Make sure the lever of the bracket assembly is engaged in the slot of the fuel rack.

4. Install the 1U5426 Compressor Assembly (5) all the way into the 8T9198 Bracket Assembly (4) to compress the spring.

5. Tighten the collet on 8T9198 Bracket Assembly (4) to hold 1U5426 Compressor Assembly (5). Spring force now holds the fuel rack against 6V4186 Timing Pin (3) in the zero position.



Fuel Injection Pump Housing
(3) 6V4186 Timing Pin. (6) 8T5287 Wrench. (7) 6V7050 Compressor Group. (8) Retainer bushing.

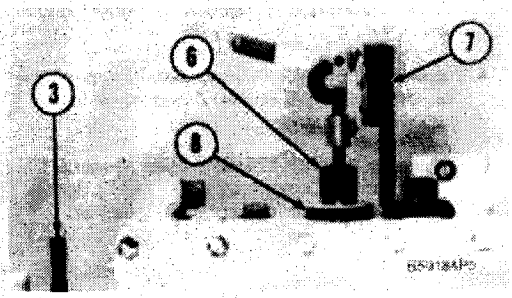
6. Remove the fuel injection line from the pump to be removed and also the fuel injection lines on each side of the pump to be removed.

⚠ WARNING

There is spring force on the fuel injection pump plunger and barrel assembly. Removal of retainer bushing (8) without the 6V7050 Compressor Group correctly installed can cause bodily injury.

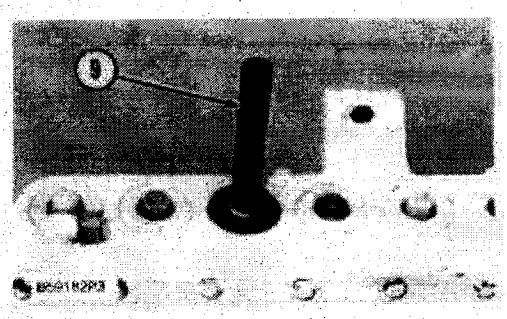
7. Use 8T5287 Wrench (6) to loosen retainer bushing (8) one quarter turn. Do not remove the bushing at this time.

8. Install 6V7050 Compressor Group (7) on the pump housing over 8T5287 Wrench (6). Lower the screw in the compressor ram to the fuel line seat before the nut is tightened to hold the compressor group in position. This centers the compressor group.



Fuel Injection Pump Housing
(3) 6V4186 Timing Pin. (6) 8T5287 Wrench. (7) 6V7050 Compressor Group. (8) Retainer bushing.

9. Use 8T5287 Wrench (6) to loosen retainer bushing (8) until it is out of the threads. Slowly raise the compressor tool handle to release the spring force.



Fuel Injection Pump Housing
(9) 8S2244 Extractor.

10. Remove the 6V7050 Compressor Group and the 8T5287 Wrench. Install 8S2244 Extractor (9) on the injection pump threads. Carefully pull the pump straight up and out of the pump housing bore. Remove the spacer from the pump housing bore.

Be careful when an injection pump is disassembled. Do not damage the surface on the plunger. The plunger and barrel 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 into the bore of the barrel. When injection pumps are removed from the fuel injection pump housing, keep the parts together so they can be installed in the same location in the housing.

Installation Of Fuel Injection Pump

NOTICE

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

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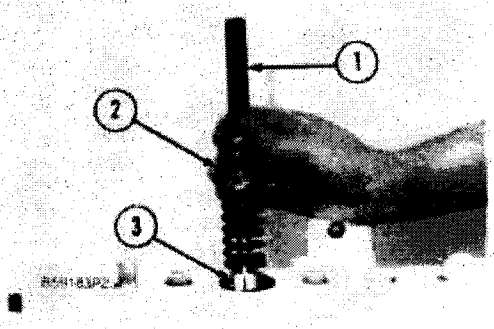
1. Put the fuel rack in the center position. See Removal of Fuel Injection Pumps for this procedure.



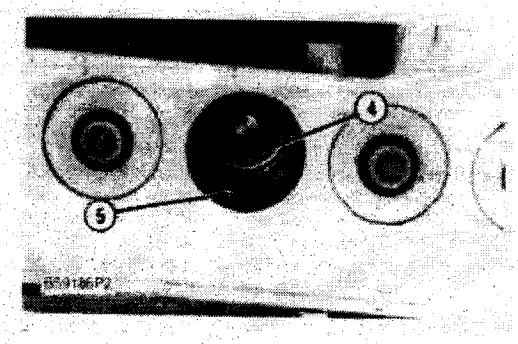
Fuel Injection Pump Installation
(1) 8S2244 Extractor. (2) Pump barrel. (3) Gear segment.

2. Put 8S2244 Extractor (1) on the threads of the fuel injection pump.

3. Make sure the lifter for the pump to be installed is at the bottom of its travel (can lobe is at its lowest point).

4. Put the groove in pump barrel (2) in alignment with the slot (groove) in gear segment (3).

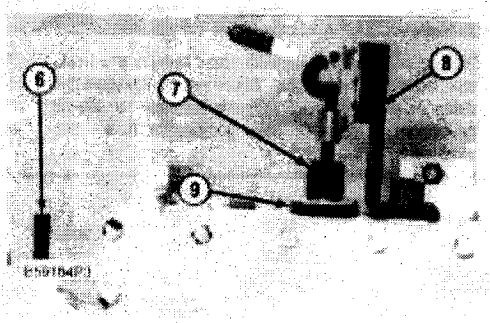
5. Be sure the spacer is in position in the pump housing bore.



Fuel Injection Pump Housing (Top View)
(4) Pin. (5) Dowel.

6. Carefully install the pump straight down into the pump housing bore.

NOTE: The slot (groove) in gear segment (3) must be in alignment with pin (4) in the side of the lifter and the groove in barrel (2) must be in alignment with dowel (5) in the housing bore.



Fuel Injection Pump Housing
(6) 6V4186 Timing Pin. (7) 8T5287 Wrench. (8) 6V7050 Compressor Group. (9) Retainer bushing.

7. Remove the 8S2244 Extractor. Put the O-ring seal, retainer bushing (9) and 8T5287 Wrench (7) in position on the top of the injection pump. Install 6V7050 Compressor Group (8).

8. Slowly move the handle of the 6V7050 Compressor Group down to push the injection pump into the bore.

NOTICE

The handle of the 6V7050 Compressor Group must move smoothly down to the lock position. Do not force the handle if it stops. If the handle does not move smoothly down to the lock position, raise the handle, remove the 6V7050 Compressor Group, and repeat Steps 3 through 8.

---

9. Put the O-ring seal in position in the pump housing bore. Use the 8T5287 Wrench to install the retainer bushing.

10. Remove the 6V7050 Compressor Group. Tighten the retainer bushing to 270 ± 13 N·m (199 ± 10 lb ft).

NOTICE

The bushing must be tightened to the correct torque. 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.

11. Install the fuel injection lines to the pump and tighten to 42 ± 7 N·m (31 ± 5 lb ft) Injection lines in this section for more information.

⚠ WARNING

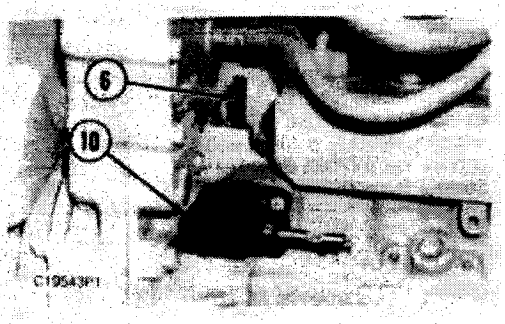
Be sure the fuel injection line clamps are installed in the correct locations. Incorrectly installed clamps may allow the fuel injection lines to vibrate and become damaged. The damaged lines may leak and cause a fire.

The following steps can be used to insure correct installation and operation of any number of individual replacement pumps on most truck engines.

12. Remove or activate the shutoff solenoid if it is installed in the rack actuator housing.

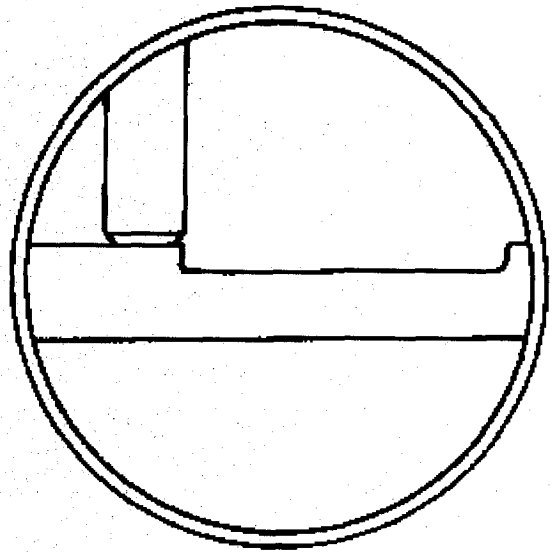
NOTE: The manual shutoff override lever can be used to move the shutoff solenoid out of the way so the fuel rack can be moved.

NOTE: To check the installation of a replacement pump, it is necessary to have full rack travel in both directions. The actual zero location of the timing pin and rack are not used to check the installation of replacement pumps.



Check Fuel Rack Travel
(6) 6V4186 Timing Pin. (10) 8T9198 Bracket Assembly.

13. Remove the compressor and bracket assembly (10) from the fuel injection pump housing.

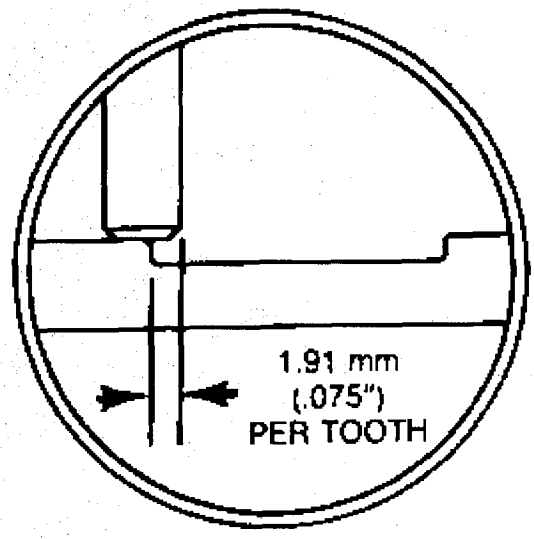


C14681P1

Illustration 1. Correct installation in full load position.

14. Raise the timing pin and move the rack to the full load position. Use finger pressure to be sure the rack is at full rack travel (beyond full load position).

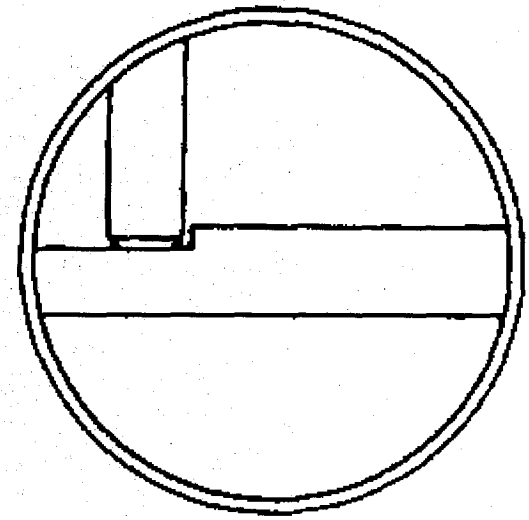
15. If the fuel injection pump installation is correct, when the timing pin is lowered it will be on the rack as shown in Illustration 1.



C14682P1

Illustration 2. Incorrect installation, full load position restricted by less than full rack travel.

16. If the fuel injection pump installation is **not** correct, the timing pin position will be approximately 1.91 mm (.075 in) toward the slot for each tooth position out of alignment (see Illustration 2). This will reduce fuel rack travel, even though it may not affect the rack setting, because of additional rack travel at static conditions.

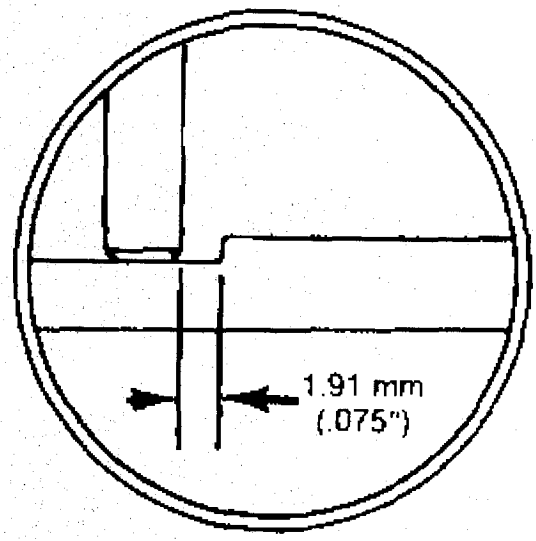


C14683P1

Illustration 3. Correct installation at no load (fuel off) position.

17. Raise the timing pin and move the rack to the no load (fuel off) position.

18. If the fuel injection pump installation is correct, when the timing pin is lowered it will be in the timing slot, less than 1.91 mm (.075 in) from the rear face of the slot as shown in Illustration 3.



C14684P1

Illustration 4. Incorrect installation, fuel shutoff position restricted by less than full rack travel.

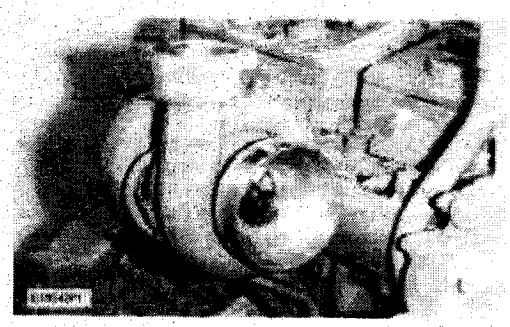
19. If the fuel injection pump installation is **not** correct, the timing pin position will be more than 1.91 mm (.075 in) from the rear face of the timing slot in the rack (see Illustration 4).

20. When all fuel injection replacement pumps are installed correctly remove 6V4186 Timing Pin (6) from the fuel injection pump housing and install the plug.

21. Install the gasket and cover over the fuel rack on the side of the fuel injection pump housing.

NOTICE

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).



Turbocharger Air Inlet Opening

a. Remove the air cleaner pipe from the turbocharger leaving the air inlet open as shown.

b. Set the governor control at low idle. No pressure applied to the accelerator pedal (up).

Stopping the Engine

⚠ WARNING

Be careful when plate is put against air inlet opening. Due to excessive suction, the plate can be pulled quickly against air inlet opening. To avoid crushed fingers, do not put fingers between plate and air inlet opening.

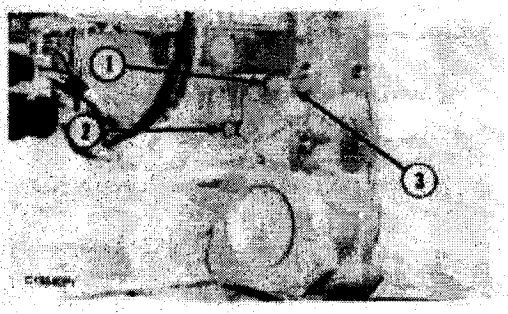
c. Start the engine, and if engine starts to overspeed (run out of control), put a steel plate over the air inlet as shown to stop the engine.

Finding Top Center Compression Position For No. 1 Piston

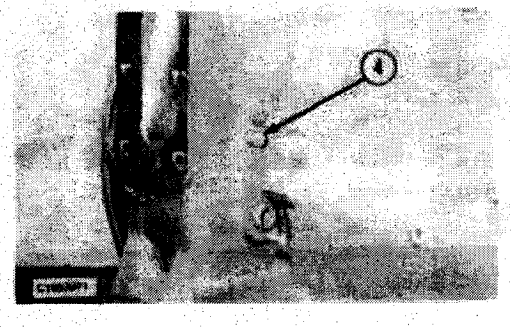
Tools Needed		
9S9082	Turning Tool	1

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

NOTE: On some engines there are two threaded holes in the flywheel. These holes are in alignment with the holes with plugs in the left and right front of the flywheel housing. The two holes in the flywheel are at a different distance from the center of the flywheel so the timing bolt cannot be put in the wrong hole.



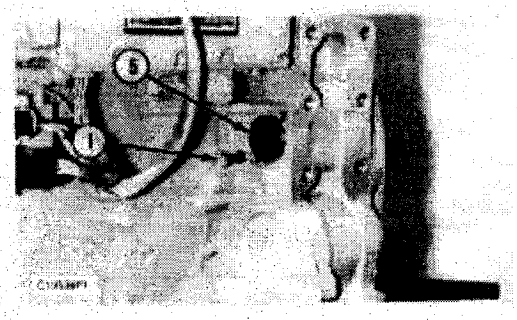
Locating Top Center (Left Side of Engine)
(1) Timing bolt. (2) Timing bolt location. (3) Storage location.



Locating Top Center (Right Side of Engine)
(4) Timing bolt location.

1. The timing bolt (1) is kept in storage at location (3) and can be installed in either the left side of the engine at timing bolt location (2) or in the right side of the engine at timing bolt location (4).

Remove bolts and cover from flywheel housing. Remove the plug from the timing hole in the flywheel housing.

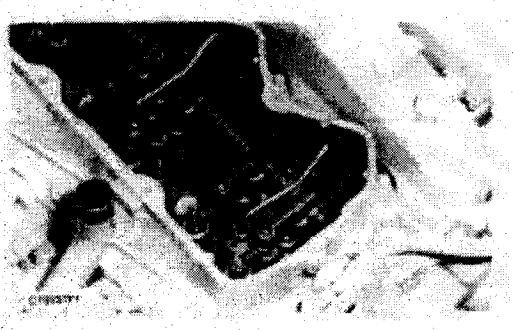


Using 9S9082 Engine Turning Tool
(1) Timing bolt. (5) 9S9082 Engine Turning Tool.

2. Put timing bolt (1) [long bolt that holds cover on the flywheel housing] through the timing hole in the flywheel housing. Use the 9S9082 Engine Turning Tool and 1/2 inch drive ratchet wrench to turn the engine flywheel in the direction of normal engine rotation until the timing bolt engages with the threaded hole in the flywheel.

NOTE: If the flywheel must be turned opposite normal engine rotation approximately 45 degrees. Then turn the flywheel in the direction of normal rotation until the timing bolt engages with the threaded hole. The reason for this procedure is to make sure the play is removed from the gears when the No. 1 piston is put on top center.

3. Remove the front valve cover from the engine.



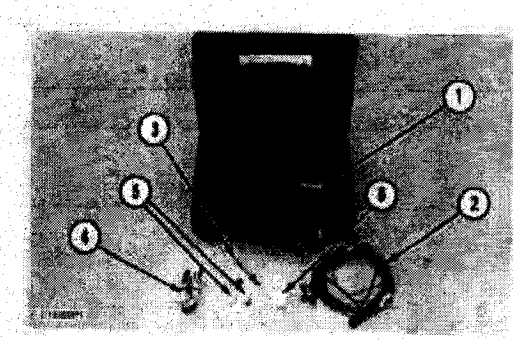
Checking No. 1 Inlet and Exhaust Valves

4. The inlet and exhaust valves for the No. 1 cylinder are closed if No. 1 piston is on the compression stroke and the rocker arms can be moved by hand. If the rocker arms can not be moved and the valves are slightly open the flywheel must be turned again.

Remove the timing bolt and turn the flywheel in the direction of normal engine rotation 360 degrees until the timing bolt can be installed. The No. 1 piston is now in the top center compression position.

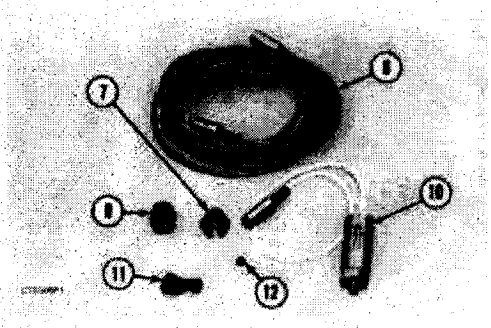
Checking Engine Timing With 8T5300 Timing Indicator Group And 8T5301 Diesel Timing Adapter Group

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 and 6V3093 Transducer Adapters. (6) 8K4644 Fuse.

The 8T5300 Timing Indicator Group must be used with the 8T5301 Diesel Timing Adapter Group.



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

⚠ WARNING

A high pressure fuel line must be disconnected. To avoid personal injury or fire from fuel spray, the engine must be stopped before the fuel line is disconnected.

When checking the dynamic timing on an engine without a mechanical advance, Caterpillar recommends that the service technician calculate and plot the dynamic timing specifications first on a worksheet like SEHS8140. See Special Instruction 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 TMI (Technical Marketing Information) or Fuel Setting and Related Information Fiche.

After the timing values are calculated and plotted, the dynamic timing should be checked with the 8T5300 Engine Timing Indicator Group. The engine must be operated from 1000 rpm (base rpm) to high idle and from high idle to 1000 rpm (base rpm). Unstable readings are often obtained below 1000

rpm. Record the dynamic timing at each 100 rpm and at the specified speeds during both acceleration and deceleration. Plot the results on the worksheet.

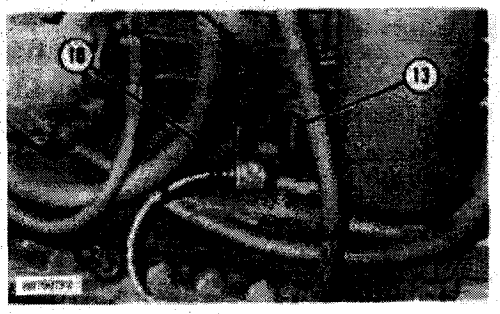
Inspection of the plotted value will show if the fuel injection timing is within specifications and if it is advancing correctly.

1. See the Engine Information Plate for the performance specification number and make reference to the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct timing specifications to use.

2. Make reference to Operation Instructions inside the lid of the 8T5300 Timing Indicator Group or Special Instruction SEHS8580 for complete instructions and calibration.

⚠ 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 against the flywheel.



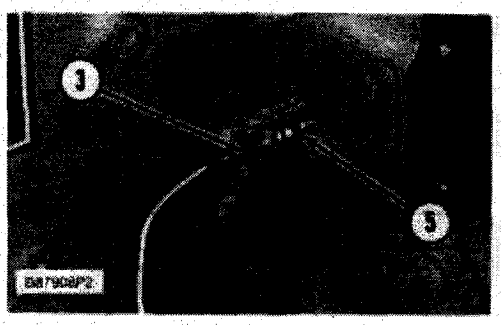
Transducer In Position (Typical Example)
(10) Injection transducer. (13) Fuel injection line (for No. 6 cylinder).

3. Loosen all fuel line clamps that hold No. 6 fuel injection line, and disconnect fuel injection line (13) for the No. 6 cylinder at the fuel injection pump. Slide the nut up and out of the way. Put 5P7436 Adapter (9) in its place and turn 5P7436 Adapter (9) onto the fuel pump bonnet until the top of the bonnet threads are approximately even with the bottom of the "window" in the adapter.

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

5. Put fuel injection line (13) on top of 5P7435 Tee Adapter (11). Install 5P7437 Adapter (7), and tighten to 42 ± 7 N·m (31 ± 5 lb ft).

6. Remove the plug from the flywheel housing. Install transducer adapter (5) into the hole the plug was removed from. Tighten only a small amount.



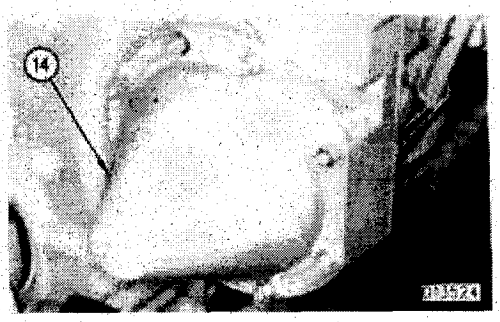
Transducer In Position
(3) Magnetic transducer. (5) Transducer adapter.

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

8. Connect the cables from the transducers to 8T5250 Engine Timing Indicator (1). Calibrate and make adjustments. For calibration procedure, make reference to Special Instruction SEHS8580.

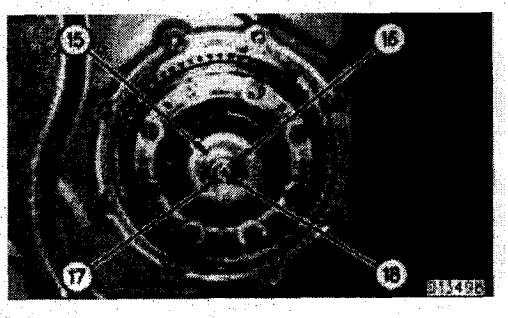
9. Start the engine, and let it reach operating temperature. Then run the engine at approximately one-half throttle for eight to ten minutes before measuring timing.

10. Run the engine at the speeds required, and record the timing indicator readings. If the engine timing is not correct, make reference to Checking Engine Timing By Timing Pin Method for static adjustment of the fuel injection pump drive. If the timing advance is not correct, do the steps that follow to make an adjustment.

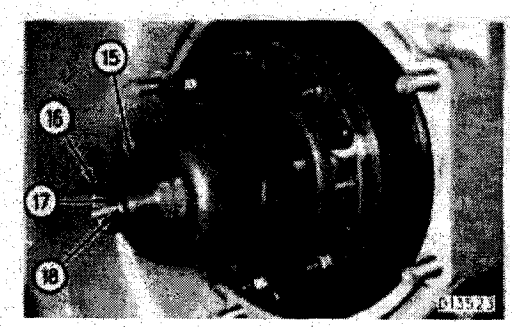


Front Of Engine
(14) Access cover (for governor and fuel pump drive group).

11. Stop the engine and remove access cover (14).



Automatic Timing Advance Unit (Governor And Fuel Pump Drive Group)
(15) Locknut. (16) Screw. (17) Locknut. (18) Setscrew.

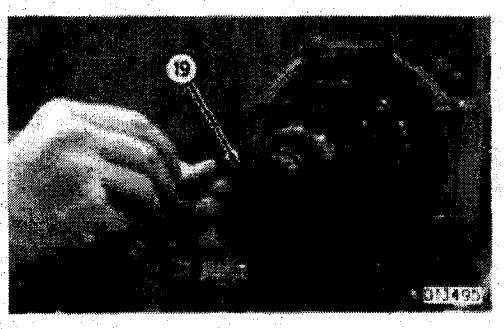


Automatic Timing Advance Unit (Typical Example)
(15) Locknut. (16) Screw. (17) Locknut. (18) Setscrew.

12. If the adjustments are being made because of an engine horsepower rating change or for replacement of parts, start with an initial setting as follows:

a. Adjustment screw (16) must extend out from the retainer approximately 27.9 mm (1.10 in).
b. Setscrew (18) must be below the end of screw (16) approximately 17.78 mm (.700 in) on an engine with 11 degree timing advance and 19.05 mm (.750 in) on an engine with 10 degree timing advance.

13. To adjust the speed where the fuel injection timing starts to advance, loosen locknut (15) and turn screw (16). Turn screw (16) clockwise to increase the speed where the timing advance starts. Tighten locknut (15) to a torque of 70 ± 15 N·m (50 ± 11 lb ft).



Adjust Speed Where Advance Stops (Typical Example)
(19) 6V2105 Tool Group.

NOTE: If the speed where timing advance starts is adjusted, the speed where the automatic timing advance stops should also be adjusted.

14. To adjust the speed where the fuel injection automatic timing advance stops, loosen locknut (17) and turn setscrew (18) clockwise to decrease the stop speed. Tighten locknut (17) to a torque of 4.5 ± 0.5 N·m (40 ± 4 lb in). 6V2105 Tool Group (19) [part of 6V6070 Governor Adjusting Tool Group] can be used to make this adjustment.

15. After each adjustment, install cover (14) and recheck the automatic timing advance with the 8T5300 Timing Indicator Group.

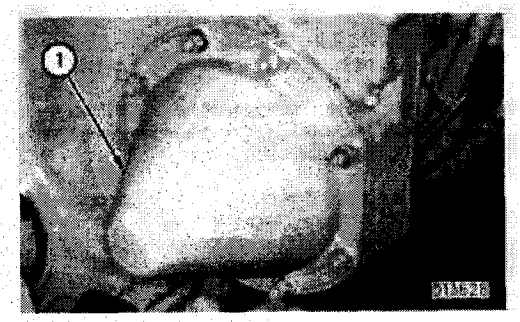
16. If the automatic timing advance unit cannot be adjusted to operate within the correct range, or the operation of the unit is not smooth, repair or replace the automatic timing advance unit (governor and fuel pump drive group).

Checking Engine Timing By Timing Pin Method

Tools Needed		
9S9082	Engine Turning Tool	1
6V4186	Timing Pin	1
1U8271	Timing Advance Holding Tool	1
8T5300	Engine Timing Indicator Group	1
8T5301	Diesel Timing Adapter Group	1

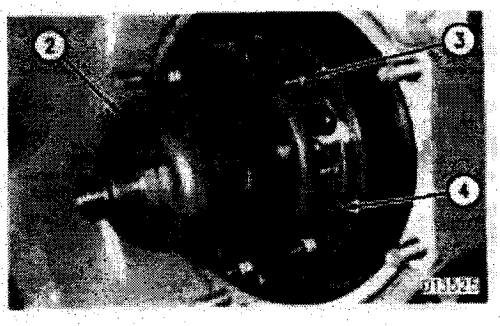
1. Put No. 1 piston at top center on the compression stroke. Make reference to Finding Top Center Compression Position For No. 1 Piston. Remove the timing bolt from the flywheel and use 9S9082 Engine Turning Tool to rotate the crankshaft clockwise 45 degrees as seen from the flywheel end of the engine.

NOTE: The crankshaft can be turned from the front of the engine by using a wrench on the vibration damper bolts, if necessary.



Front Of Engine (Typical Example)
(1) Access cover [for automatic timing advance (governor and fuel pump drive group)].

2. Remove timing advance access cover (1).



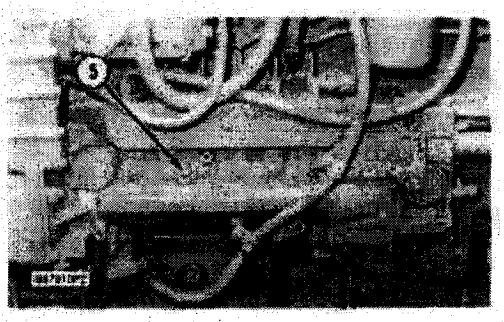
Timing Advance Unit (Typical Example)
(2) Retainer. (3) Nuts. (4) Bolts.

3. Loosen nuts (3) and remove retainer (2) and the flyweight spring from the timing advance unit. Make sure that the flyweight spring does not fall out and get lost.

NOTE: Do not loosen the locknuts and adjustment screws in the end of retainer (2). If the adjustment screws are moved from their original settings, the dynamic engine timing must be set by using the 8T5300 Timing Indicator Group after the static timing pin procedure is completed.

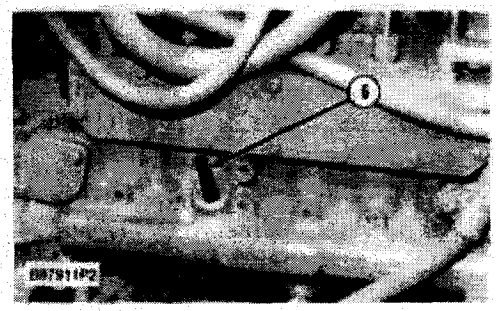
4. Loosen bolts (4) that hold the timing advance unit together.

5. Tighten bolts (4) to a torque of 1.8 ± 0.3 N·m (16 ± 3 lb in). This puts a slight clamping force on the fuel pump drive gear to hold it in position. Also, the fuel pump camshaft can be turned or held in position separate from the engine crankshaft. The drive gear is allowed to slip.



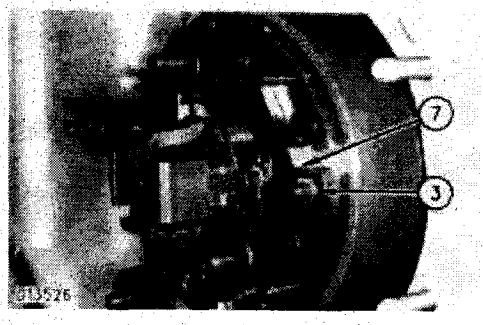
Fuel Injection Pump
(5) Plug (timing pin hole).

6. Remove plug (5) from the fuel injection pump housing.



Timing Pin Installed
(6) 6V4186 Timing Pin.

7. With No. 1 piston 45 degrees before Top Center, slowly rotate the crankshaft counterclockwise (as seen from the flywheel end of the engine) until 6V4186 Timing Pin (6) goes into the slot in the fuel pump camshaft and the timing bolt can be installed in the timing hole in the flywheel.



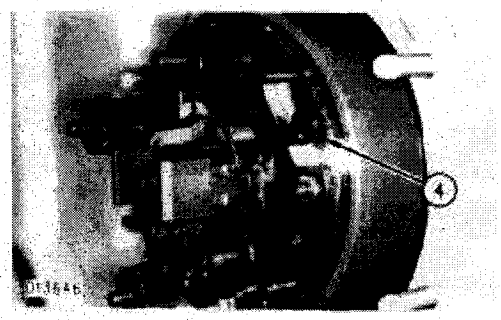
Install Holding Tool (Typical Example)
(3) Nut. (7) 1U8271 Holding Tool.

8. Install the 1U8271 Holding Tool (7) and push the timing advance unit piston back as follows:

a. Turn the knurled nuts on the holding tool out until each stud is 6.4 mm (.25 in) below the surface of the nut.

b. Put 1U8271 Holding Tool (7) in position on the cap screws that hold retainer (2). Install and tighten nuts (3) finger tight. Make sure that the four tangs on the loose inner ring of the holder tool are positioned at the corners of the four flyweights and flyweights are free to move.

c. Tighten the four large knurled nuts evenly by hand until a positive stop is felt. No external component contact can be seen. The positive stop is the timing advance piston making contact at the bottom of its travel. This step makes sure that the timing advance unit is in its most retarded timing position.



Tighten Drive Bolts And Remove Tooling (Typical Example)
(4) Bolts.

9. Tighten the four bolts (4) to a torque of 55 ± 7 N·m (41 ± 5 lb ft).

10. Remove holding tool from the automatic timing advance unit.

11. Remove the timing pin bolt from the flywheel and 6V4186 Timing Pin (6) from the fuel injection pump housing.

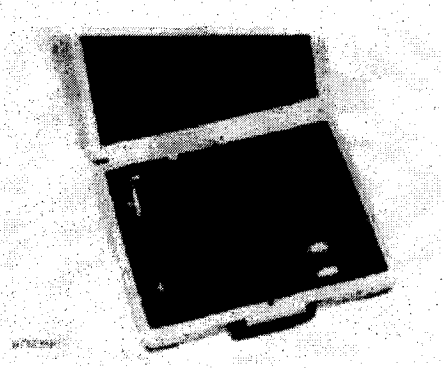
12. Install the flyweight spring and retainer (2) on the timing advance unit. Make sure the spring is in its correct position and tighten the four nuts to hold the retainer in position.

13. Install access cover (1) on the timing gear housing and plug (5) in the fuel injection pump housing.

14. If necessary, check the dynamic timing of the engine with the 8T5300 and 8T5301 Tool Groups. Make reference to Special Instructions, SEHS8580, for the correct installation and operation of the tool groups. Also, see Checking Engine Timing With 8T5300 Timing Indicator Group And 8T5301 Diesel Timing Adapter Group for the procedure to check the dynamic timing of the engine.

Fuel Setting Procedure

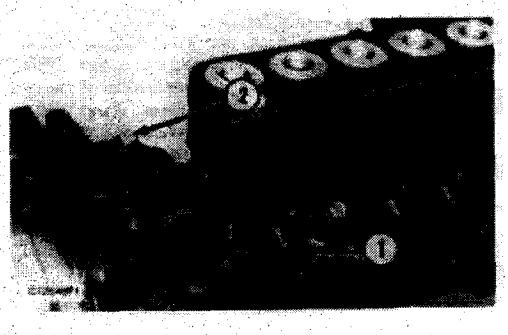
Tools Needed		
6V6070	Governor Adjusting Tool Group	1
8T0500	Circuit Tester	1
8T1000	Electronic Position Indicator Group (Optional)	1



6V6070 Governor Adjusting Tool Group

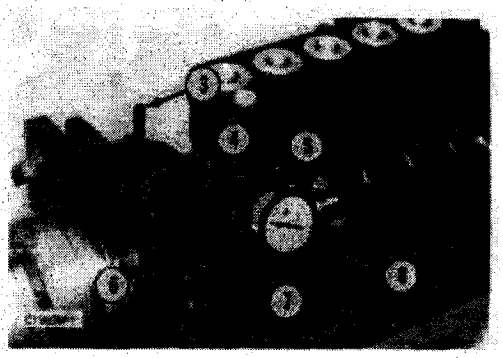
NOTE: If the 8T1000 Electronic Position Indicator Group is used, make reference to Special Instruction SEHS8623 for information on the use of the tool group.

The fuel setting procedure can be used with the fuel injection pump and governor on or off the engine.



Fuel Injection Pump And Governor
(1) Cover (rack position indicator). (2) Plug (rack centering pin).

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

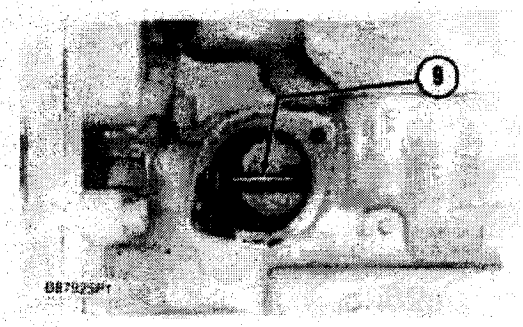


Indicator And Centering Pin Installed
(3) 6V4186 Timing Pin. (4) 8T9198 Bracket Assembly. (5) 2A0762 Bolt (1/4-20 NC × .625 in). (6) 8H9178 Ground Body Bolt (1/4-20 NC × 1.00 in). (7) 5P4814 Collet. (8) 6V6106 Dial Indicator.

NOTE: If the 8T1000 Position Indicator Group is used instead of the dial indicator, use Step 3 for the installation of the probe.

2. Install the rack position indicator as follows:

a. Install the 5P4814 Collet (7) on the 8T9198 Bracket Assembly (4).



Slot In Fuel Injection Pump Rack
(9) Slot.

b. Position the indicator arm in approximately the middle of its travel to make sure that it will engage in slot (9) in the rack. Put 8T9198 Bracket Assembly (4) in position on the fuel injection pump housing.

c. Install 8H9178 Ground Body Bolt (6) first. Then install 2A0762 Bolt (5).

d. Be sure the indicator arm moves freely.

e. Put 6V6106 Dial Indicator (8) in position in 5P4814 Collet (7).

f. Put the 9S8903 Contact Point on the 6V2030 Extension and install on 6V6106 Dial Indicator (8).

NOTE: The 9S8903 Contact Point will not go through the collet and must be assembled after the indicator stem has passed through the collet.

g. Tighten 5P4814 Collet (7) just enough to hold the dial indicator.

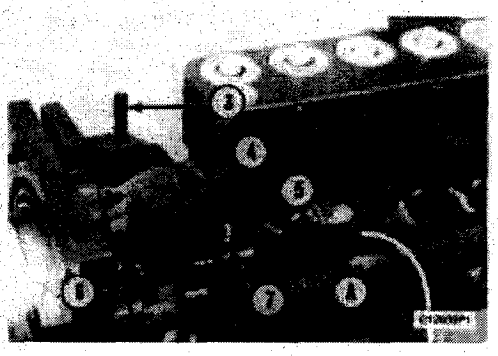
3. Install the rack position probe as follows:

a. Install the 5P4814 Collet (7) on the 8T9198 Bracket Assembly (4).

b. Position the indicator arm in approximately the middle of its travel to make sure that it will engage in slot (9) in the rack. Put 8T9198 Bracket Assembly (4) in position on the fuel injection pump housing.

c. Install 8H9178 Ground Body Bolt (6) first. Then install 2A0762 Bolt (5).

d. Be sure the indicator arm moves freely.



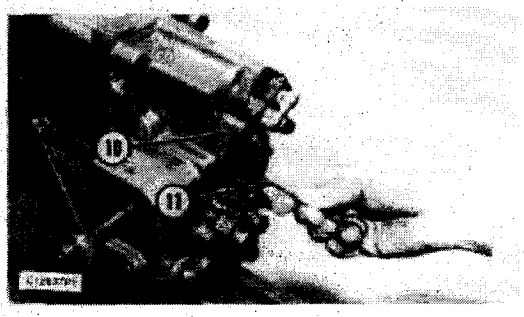
Probe And Centering Pin Installed
(3) 6V4186 Timing Pin. (4) 8T9198 Bracket Assembly. (5) 2A0762 Bolt (1/4-20 NC × .625 in). (6) 8H9178 Ground Body Bolt. (1/4-20 NC × 1.00 in). (7) 5P4814 Collet. (A) 8T1002 Probe.

e. Put probe (A) in position in 5P4814 Collet (7).

f. Put the 9S8903 Contact Point on the 6V2030 Extension and install on 8T1002 Probe (A).

NOTE: The 9S8903 Contact Point will not go through the collet and must be assembled after the indicator stem has passed through the collet.

9. Adjust 8T1002 Probe (A) in 5P4814 Collet (7) so that the shaft can be moved through the entire measurement range without reaching the end of the shaft travel. Tighten the collet.



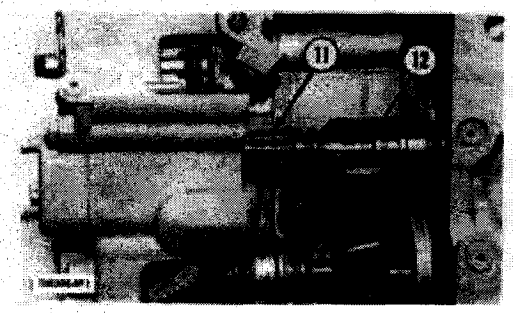
Position Fuel Injection Pump Rack
(10) 6V6151 Adapter. (11) 6V7942 Hook.

4. Remove the shutoff solenoid, if so equipped, or cover and install the 6V6151 Adapter (10).

5. Move the governor control lever to the "LOW IDLE" position (rotate governor shaft counterclockwise).

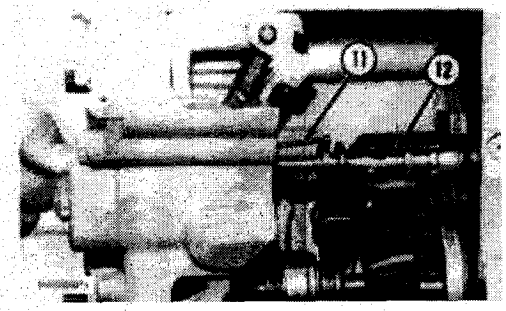
6. Install the 6V4186 Timing Pin (3) in the top of the fuel injection pump housing. Push the timing pin in until contact with the fuel rack is made.

7. Use 6V7942 Hook (11) through 6V6151 Adapter (10) to **push** the sleeve and rack to the "SHUTOFF" position. Make sure 6V4186 Timing Pin (3) engages in slot (9).



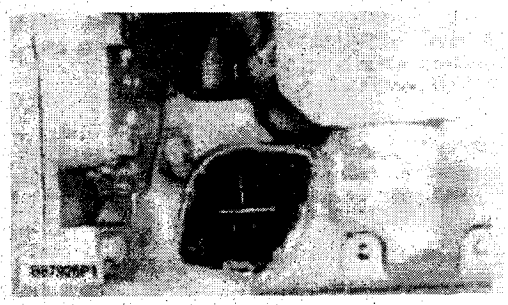
Push Rack To Shutoff
(11) 6V7942 Hook. (12) Servo valve.

8. Move the governor control lever to the "FULL LOAD" position (rotate governor shaft clockwise) and fasten it in this position.



Pull Rack Against Timing Pin
(11) 6V7942 Hook. (12) Servo valve.

9. Use the 6V7942 Hook (11) to pull the sleeve and rack [through servo valve (12)] against the timing pin.

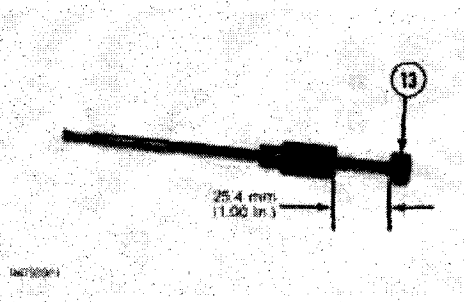


Fuel Rack Against Timing Pin

10. Adjust the 6V6106 Dial Indicator (8) in the collet to zero and tighten the collet. Make sure all needles of the indicator are on zero.

NOTE: If the Electronic Position Indicator Group is used, press the ZERO switch on the front panel. This sets the display to zero.

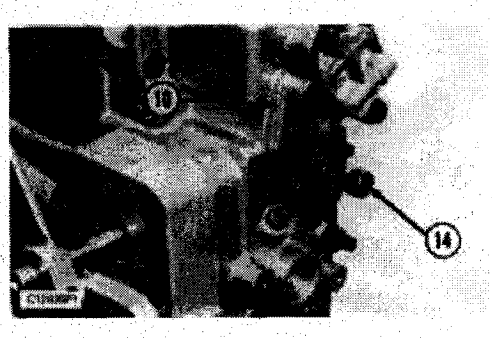
11. Remove the 6V4186 Timing Pin (3), 6V7942 Hook and release the governor control lever.



6V7941 Compressor Assembly
(13) Rod.

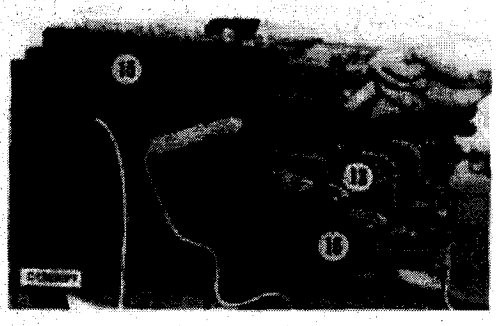
12. Turn rod (13) in the 6V7941 Compressor Assembly until the knob is approximately 25.4 mm (1.00 in) away from the compressor body.

NOTE: The 6V7941 Compressor Assembly is used to compress the overfueling spring through the linkage. The overfueling spring must be compressed to get an accurate fuel setting measurement.



Install The 6V7941 Compressor Assembly
(10) 6V6151 Adapter. (14) 6V7941 Compressor Assembly.

13. Install 6V7941 Compressor Assembly (14) in 6V6151 Adapter (10) as shown.



Static Fuel Setting
(13) Rod (part of 6V7941 Compressor Assembly). (15) 8T0500 Circuit Tester. (16) Insulated terminal.

14. Fasten the clip end of the 8T0500 Circuit Tester (15) to insulated terminal (16), and put the other end to a good electrical ground.

NOTE: If the Electronic Position Indicator Group is used, the built-in continuity tester can be used instead of 8T0500 Circuit Tester (15). Use the built-in tester only for static readings.

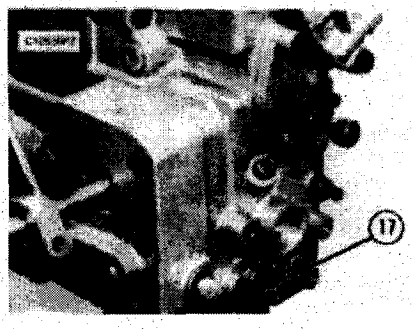
15. Hold the governor control lever in the "FULL LOAD" position (rotate governor shaft clockwise).

16. Turn rod (13) of compressor assembly in (clockwise) until the light in 8T0500 Circuit Tester (15) goes off and the dial indicator hands move an additional 2 mm in the negative (-) direction after the light goes out (2 complete revolutions of the large needle on the dial indicator).

NOTICE

DO NOT turn the rod any further in if the rod begins to tighten.
Damage to the governor can occur if the rod is turned in further.

NOTE: The static fuel setting (Step 18) and the static full torque setting (Step (19) must be within ± .25 mm of the setting on the Engine Information Plate. If the setting is within ± .25 mm an adjustment is not necessary. If the Engine Information Plate is gone or the Full Torque Setting is not on the Engine Information Plate, see TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct settings.



Adjustment Of Governor
(17) Adjustment screw cover.

17. Remove adjustment screw cover (17) from the rear of the governor housing.

18. Slowly turn rod (13) out (counterclockwise) until the circuit tester light just comes on. This is the static fuel setting. See the Engine Information Plate or the Fuel Setting And Related Information Fiche for the correct **static fuel setting**.

NOTE: When the rod is turned out, there can be a small initial movement of the dial indicator hands, then, they will stop moving while the rod is turned out for approximately another 11/2 turns. Now the indicator hands will begin to move again and will follow the turning of the rod until the setting is

reached. It is important that the rod be turned slowly so that the rack can follow the governor components.

NOTE: If rod (13) is turned out too fast, a wrong measurement can be read on the dial indicator as the light comes on. Repeat Steps 16 and 18 to make sure the correct measurement is taken.

19. Continue to turn the rod out until the indicator hand stops moving. Then turn the rod out two additional turns. Push in on the rack stop collar to make sure it is in the correct position. The new reading on the indicator is the **full torque static setting.**

Example:

Static Fuel Setting = 2.18 mm

Full Torque = 3.18 mm

This means the torque rise setting is 1.00 mm. An addition of the fuel setting and the torque rise setting is not necessary.

20. See the Engine Information Plate for the correct static full torque setting.

21. Determine how much the settings will have to be changed (see examples). Use the chart that follows to determine how far the adjusting screws must be turned.

Adjustment Screw Chart	
Amount Of Change	**Turns Of Adjustment Screw**
3.00 mm (.118 in)	3¾
2.79 mm (.110 in)	3½
2.59 mm (.102 in)	3¼
2.39 mm (.094 in)	3
2.21 mm (.087 in)	2¾
2.01 mm (.079 in)	2½
1.80 mm (.071 in)	2¼
1.60 mm (.063 in)	2
1.40 mm (.055 in)	1¾
1.19 mm (.047 in)	1½
0.99 mm (.039 in)	1¼
0.79 mm (.031 in)	1
0.61 mm (.024 in)	¾
0.41 mm (.016 in)	½
0.20 mm (.008 in)	¼

Example #1

Actual Reading:	1.05 mm
Desired Setting:	1.25 mm
Difference:	0.20 mm

Since "desired setting" is **higher** than "actual reading," turn adjusting screw **out** (counterclockwise) approximately 1/4 turn. **Recheck the new setting** and readjust if necessary.

Example #2

Actual Reading:	2.77 mm
Desired Setting:	1.85 mm
Difference:	0.92 mm

Since "desired setting" is **lower** than "actual reading," turn the adjusting screw **in** (clockwise) approximately 11/8 turns. **Recheck the new setting** and readjust if necessary.

Example #3

Actual Reading:	−1.05 mm
Desired Setting:	−1.25 mm
Difference:	0.20 mm

Negative numbers work differently than positive numbers. If one number (-1.25) has a larger digital value than another one (-1.05), the first number (-1.25) is actually less than the other one. Therefore, in this example the "desired setting" is **lower** than the "actual reading". Turn the adjusting screw **in** (clockwise) approximately 1/4 turn. **Recheck the new setting** and readjust if necessary.

Example #4

Actual Reading:	−2.77 mm
Desired Setting:	−1.85 mm
Difference:	0.92 mm

The "desired setting" is **higher** than the "actual reading". Turn the adjusting screw **out** (counterclockwise) approximately 11/8 turns. **Recheck the new setting** and readjust if necessary.

Example #5

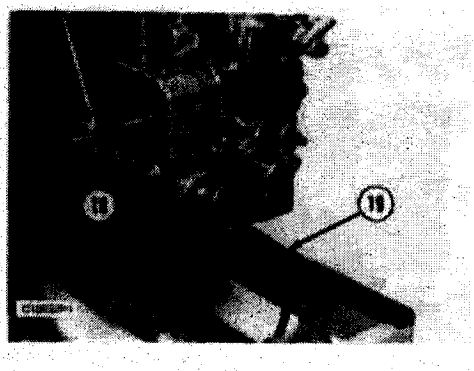
Actual Reading:	+1.05 mm
Desired Setting:	−1.25 mm
Difference:	2.30 mm

The "desired setting" is **lower** than the "actual reading". Turn the adjusting screw **in** approximately 27/8 turns.

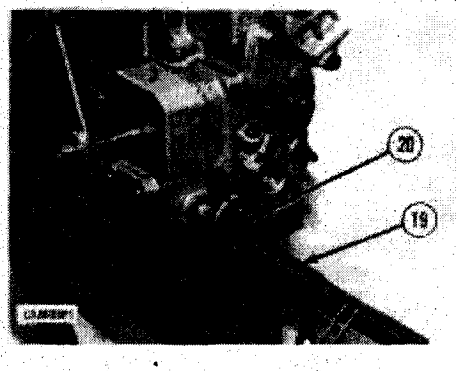
Example #6

Actual Reading:	−1.05 mm
Desired Setting:	+1.25 mm
Difference:	2.30 mm

The "desired setting" is **higher** than the "actual reading". Turn the adjusting screw out approximately 27/8 turns.



Adjustment Of Fuel Setting
(18) Fuel setting adjustment screw. (19) 6V2105 Rack Adjustment Tool Group.



Adjustment Of Full Torque Setting
(19) 6V2105 Rack Adjustment Tool Group. (20) Torque rise setting screw.

NOTE: If you are working from the side of the engine and cannot see the adjusting screws, use the **outer edge** of the opening in the governor housing to guide the 6V2105 Tool Group onto the fuel setting screw. Use the **inner edge** of the opening to guide the 6V2105 Tool Group onto the full torque setting adjustment screw.

22. If both settings are to be increased, turn torque rise adjustment screw (20) out (counterclockwise) the same number of turns as fuel setting adjustment screw (18) is going to be changed. If the static fuel setting is going to be decreased, it is not necessary to change the full torque setting at this time.

23. Use 6V2105 Rack Adjustment Tool Group (19) to loosen the locknuts for adjustment screws and to turn the adjustment screws.

24. Adjust the fuel setting screw the number of turns determined in Step 21. Always recheck the setting after each adjustment and adjust again if needed.

NOTE: There is a **zero** tolerance for the fuel setting and full torque setting when an adjustment is made.

25. After the static fuel setting is correct, adjust the torque rise adjustment screw the number of turns determined in Step 21. Always recheck the setting after each adjustment and adjust again if needed.

Fuel Ratio Control And Governor Check

Tools Needed		
2W9161	Manual Shutoff Group	1
6V4186	Timing Pin	1
6V6070	Governor Adjusting Tool Group	1

NOTE: The governor seals **do not** have to be cut or removed for the procedure that follows.

1. Install the rack position indicator to measure fuel rack movement. See Steps 1 and 2 in the Fuel Setting Procedure for the correct installation of the tooling.

2. Turn the engine start key to the ON position to activate the shutoff solenoid. Do not start the engine at this time.

3. Move the governor control linkage to the full FUEL ON position and hold or fasten it in this position.

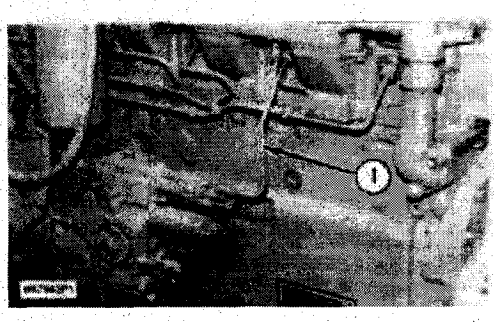
4. Install the 6V4186 Timing Pin in the rack zeroing hole near the front of the fuel injection pump housing.

5. With the governor control lever in the full FUEL ON position, use a 1N9954 Lever and move the manual shutoff shaft slowly to the FUEL OFF position (counterclockwise). Watch and make sure the timing pin drops and engages with the slot in the fuel rack.

6. Release the manual shutoff shaft and zero the dial indicator. Move the dial indicator in the collet to zero and tighten the collet. Make sure all three needles of the indicator are on zero.

7. Remove the 6V4186 Timing Pin and watch the dial indicator movement. The indicator should show movement in the FUEL ON direction. If no movement occurs repeat Steps 4, 5 and 6 to zero the indicator.

8. Release the governor control shaft and linkage.



Remove Boost Line
(1) Air Line.

9. Remove air line (1) from the engine. Put plugs over the openings to keep dirt out of the system.

⚠ WARNING

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

10. Start the engine and operate it for a minimum of five minutes to get the governor and engine up to normal operating temperatures.

11. Check the leak down rate of the fuel ratio control (with the engine operating at low idle) as follows:

a. Connect a pressure indicator, a shutoff valve, a pressure regulator and an air supply to fitting.

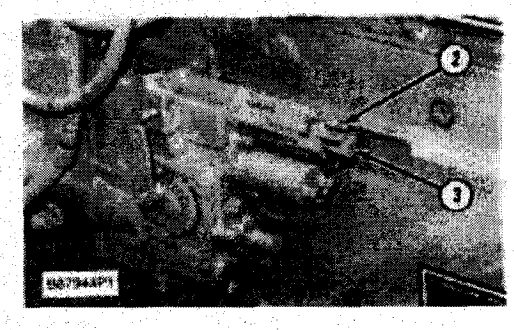
b. Apply 70 kPa (10 psi) air pressure to the fuel ratio control.

c. Turn the shutoff valve OFF 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, the fuel ratio control must be repaired before Steps 13 and 14 are done.

e. Keep 70 kPa (10 psi) air pressure on the fuel ratio control for Step 12.

NOTE: Step 11 also activates the fuel ratio control for Step 12.



Apply Air Pressure
(2) Fitting. (3) Cover.

12. From low idle, rapidly move the governor control shaft to the full FUEL ON position and read the measurement on the dial indicator. Read the indicator carefully because this reading will be a maximum for only a moment. Make a record of the maximum dial indicator reading. If full measurement is not reached, increase the air pressure to make sure there is full fuel ratio control movement.

NOTE: The fuel ratio control is activated and the maximum dial indicator reading is dynamic full torque setting of the engine. This setting is 0.5 mm (.02 in) greater than the static full torque setting given on the Engine Information Plate or later engines or in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche.

NOTE: On some CARB approved engines or with fuel ratio controls out of adjustment, the fuel ratio control can activate shortly after engine startup. At this time the dial indicator reading can be the dynamic fuel ratio control setting. Continue the checking procedure to find the dynamic full torque setting at Step 16.

13. Release all air pressure from the fuel ratio control. Start at 900 rpm and rapidly move the governor control shaft to the fuel FUEL ON position and read the measurement on the dial indicator. Read the dial indicator carefully because this reading will be a maximum for only a moment. Make a record of the maximum dial indicator reading. This is the dynamic fuel ratio control setting for the engine.

14. If the dynamic fuel ratio control setting is **within** ± 0.25 mm of the specification given on the Engine Information Plate of in the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche, an adjustment is **not** necessary.

15. For adjustment of the control see Fuel Ratio Control Adjustment.

16. Check boost pressure that gives full torque rack travel as follow:

a. Connect a pressure indicator, a pressure regulator and an air supply to fitting (2).

b. Apply 25 kPa (4 psi) air pressure to the fuel ratio control.

c. Start at 900 rpm and rapidly move the governor control shaft to the full FUEL ON position and make a record of the maximum dial indicator reading.

d. Repeat this procedure several times, each time increase the air pressure 5 kPa (.5 psi).

e. Make a record of the first air pressure setting that gives full torque rack travel. Full torque rack travel was measured in Step 12.

f. This is the boost pressure that moves the fuel ratio control out of the rack control position. This pressure gives dynamic full torque rack travel.

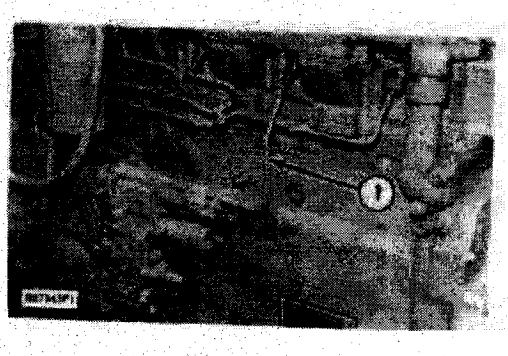
Fuel Ratio Control Adjustment

Tools Needed		
2W9161	Manual Shutoff Group	1
6V4186	Timing Pin	1
6V6070	Governor Adjusting Tool Group	1

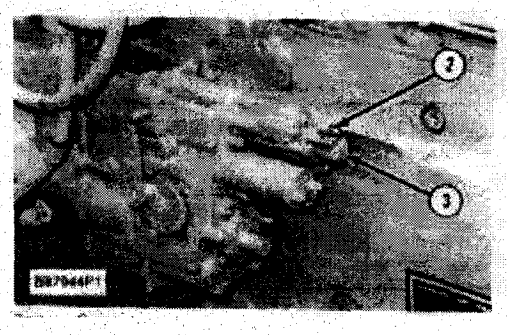
NOTE: Before the governor seals are cut or removed, See Fuel Ratio Control And Governor Check to make sure an adjustment is needed.

1. See the Engine Information Plate or the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for correct dynamic fuel ratio control setting specification before an adjustment is made.

2. Install and zero the rack position indicator group. See Fuel Ratio Control And Governor Check for this procedure.



Remove Boost Line
(1) Air line.



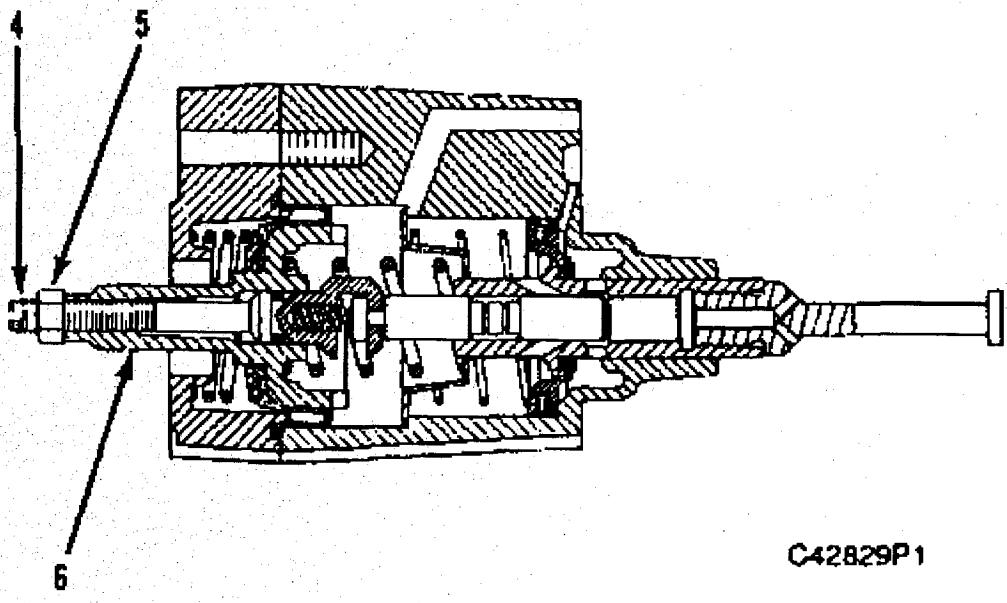
Remove Cover
(2) Fitting. (3) Cover.

3. Remove air line (1) and cover (3) from the engine.

WARNING

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

4. Start the engine and operate it for a minimum of five minutes to get the governor and engine up to normal operating temperature.



Adjustment Components.
(4) Valve extension. (5) Nut. (6) Retainer.

5. Hold retainer (6) in position and loosen nut (5). This keeps the fuel ratio control diaphragm from turning when nut (5) is loosened or tightened.

6. Turn valve extension (4) to get the correct setting. A clockwise direction gives a more positive setting. The counterclockwise direction will give a more negative setting. Several adjustments of valve extension (4) may be needed to get the correct dynamic fuel ratio control setting.

7. After each adjustment is made, check the dynamic fuel ratio control setting. Start at 900 rpm and rapidly move the governor control shaft to the full FUEL ON position and read the measurement on the dial indicator. Read the dial indicator carefully because this reading will be a maximum for only a moment. Make a record of the maximum dial indicator reading.

NOTE: If the correct dynamic fuel ratio control setting cannot be made with this adjustment, the internal governor linkage must be checked and adjusted or the fuel ratio control needs repair or replacement. See Check And Adjustment Of The Fuel Ratio Control Linkage for the governor linkage procedure.

8. After the correct adjustment has been made, tighten nut (5). Check the dynamic fuel ratio control setting again.

9. Install the gasket and cover (3) on the fuel ratio control. Tighten the bolts to a torque of 9 ± 3 N·m (7 ± 2 lb ft)

10. Apply 70 kPa (10 psi) air pressure to the fuel ratio control at fitting (2). This will fully extend the fuel ratio control to get dynamic full torque.

11. Check the dynamic full torque setting. Start at 900 rpm and rapidly move the governor control shaft to the full FUEL ON position and read the maximum measurement on the dial indicator.

NOTE: If the dynamic full torque setting cannot be reached a repair or replacement of the fuel ratio control is needed.

12. Stop the engine.

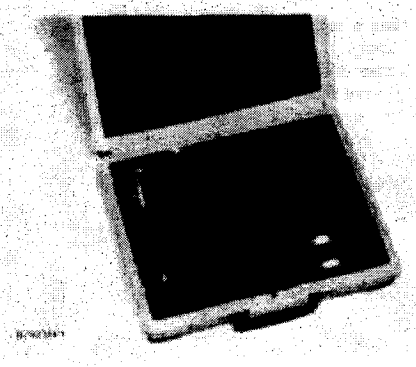
13. Install the wire and seal on the fuel ratio control.

14. Install air line (1) on the engine.

15. Remove the rack position indicator tooling.

Check And Adjustment Of The Fuel Ratio Control Linkage

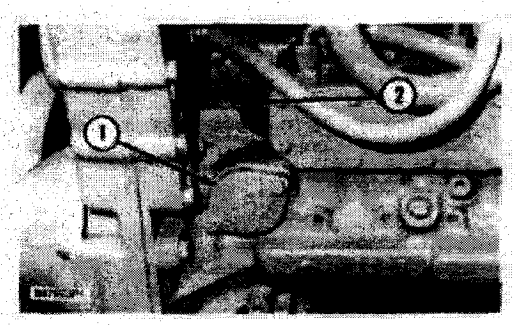
Tools Needed		
6V6070	Governor Adjusting Tool Group	1



6V6070 Governor Adjusting Tool Group

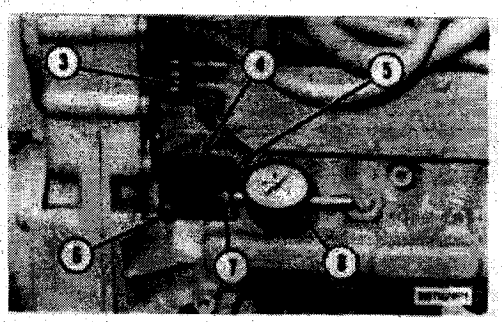
The check and adjustment of the fuel ratio control linkage can be used with the fuel injection pump and governor on or off the engine.

NOTE: Start with Step 13 of this procedure if the governor adjusting tools have already been installed to check the fuel setting.



Fuel Injection Pump And Governor
(1) Cover (rack position indicator). (2) Plug (rack centering pin).

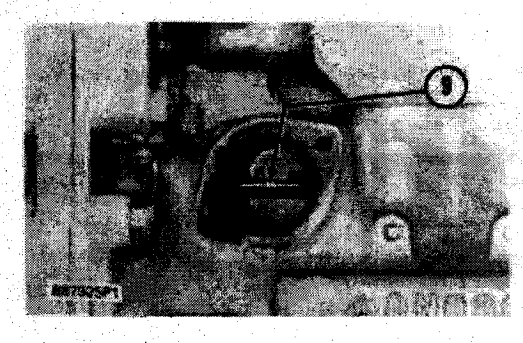
1. Remove plug (2) and cover (1) from the fuel injection pump housing.



Indicator And Centering Pin Installed
(3) 6V4186 Timing Pin. (4) 8T9198 Bracket Assembly. (5) 2A0762 Bolt. (6) 8H9178 Ground Body Bolt. (7) 5P4814 Collet. (8) 6V6106 Dial Indicator.

2. Install the rack position indicator as follows:

a. Install the 5P4814 Collet (7) on the 8T9198 Bracket Assembly (4).



Slot In Fuel Injection Pump Rack
(9) Slot.

b. Position the indicator arm in approximately the middle of its travel to make sure that it will engage in slot (9) in the rack. Put 8T9198 Bracket Assembly (4) in position on the fuel injection pump housing.

c. Install 8H9178 Ground Body Bolt (6) first. Then install 2A0762 Bolt (5).

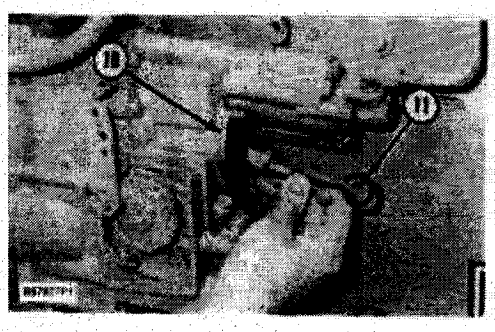
d. Be sure the indicator arm moves freely.

e. Put 6V6106 Dial Indicator (8) in position in 5P4814 Collet (7).

f. Put the 9S8903 Contact Point on the 6V2030 Extension and install on 6V6106 Dial Indicator (8).

NOTE: The 9S8903 Contact Point will not go through the collet and must be assembled after the indicator stem has passed through the collet.

g. Tighten 5P4814 Collet (7) just enough to hold the dial indicator.

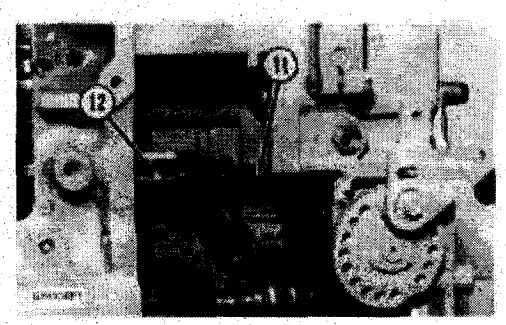


Position Fuel Injection Pump Rack
(10) 6V6151 Adapter. (11) 6V7942 Hook.

3. Remove the shutoff solenoid, if so equipped, or cover and install the 6V6151 Adapter (10).

4. Move the governor control lever to the Low Idle position (rotate governor shaft counterclockwise).

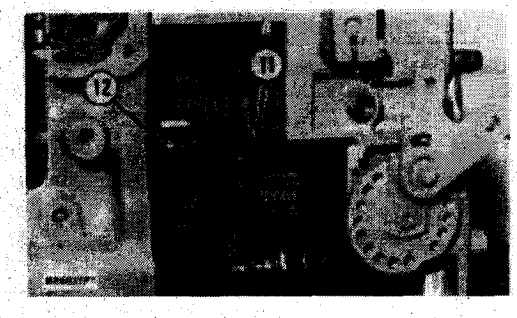
5. Install the 6V4186 Timing Pin (3) in the top of the fuel injection pump housing. Push the timing pin in until contact with the fuel rack is made.



Push Rack To Shutoff
(11) 6V7942 Hook. (12) Servo valve.

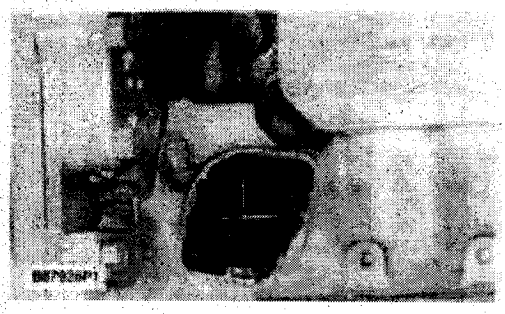
6. Use 6V7942 Hook (11) through 6V6151 Adapter (10) to **push** the sleeve and rack to the Shutoff position. Make sure 6V4186 Timing Pin (3) engages in slot (9).

7. Move the governor control lever to the Full Load position (rotate governor shaft clockwise) and fasten it in this position.



Pull Rack Against Timing Pin
(11) 6V7942 Hook. (12) Servo valve.

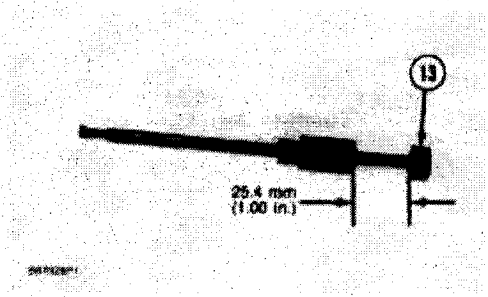
8. Use the 6V7942 Hook (11) to **pull** the sleeve and rack [through servo valve (12)] against the timing pin.



Fuel Rack Against Timing Pin

9. Adjust the 6V6106 Dial Indicator (8) in the collet to zero and tighten the collet. Make sure all three needles of the dial indicator are on zero.

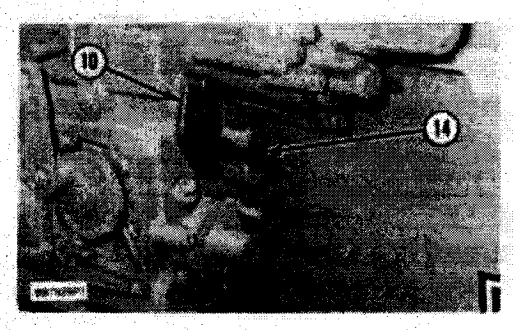
10. Remove the 6V4186 Timing Pin (3), 6V7942 Hook and release the governor lever.



6V7941 Compressor Assembly
(13) Rod.

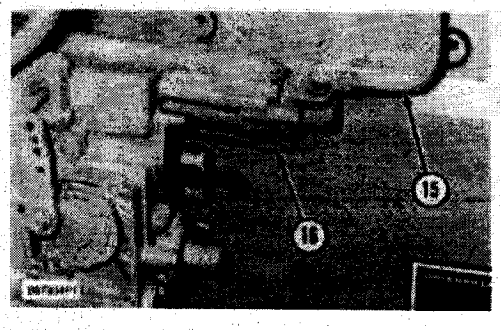
11. Turn rod (13) in the 6V7941 Compressor Assembly until the knob is approximately 25.4 mm (1.00 in) away from the compressor body.

NOTE: The 6V7941 Compressor Assembly is used to remove clearance in the governor linkage to get accurate fuel setting measurements.



Install the 6V7941 Compressor Assembly
(10) 6V6151 Adapter. (14) 6V7941 Compressor Assembly.

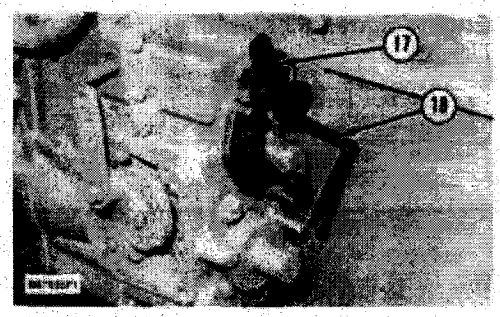
12. Install 6V7941 Compressor Assembly (14) in 6V6151 Adapter (10) as shown.



Remove Fuel Ratio Control
(15) Air supply line. (16) Fuel ratio control.

13. Remove air supply line (15) and fuel ratio control (16).

Remove Orifice Screen Assembly
(A) Location (for screen assembly).



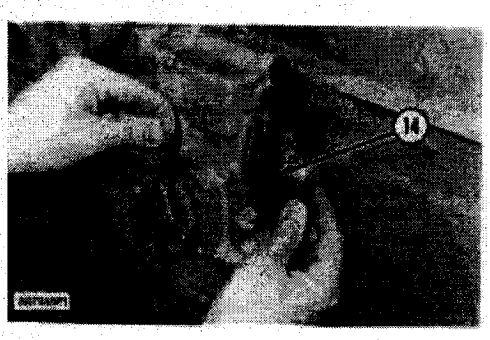
Fuel Ratio Governor Adjustment Check
(17) 6V2017 Governor Adjusting Tool. (18) 6V2105 Rack Adjusting Tool (outer part).

14. Remove the orifice screen assembly from the governor housing at location (A). This screen must be removed so 6V2017 Governor Adjusting Tool (17) can fit square against the governor housing.

NOTE: If the linkage needs any adjustment changes, install the outer part of 6V2105 Rack Adjusting Tool (18) along the left side of the governor, before bolts for tool (17) are tightened.

15. Move the governor control lever to the Low Idle position and install 6V2017 Governor Adjusting Tool (17) as shown.

16. Move the governor control lever to Full Load position and hold there.



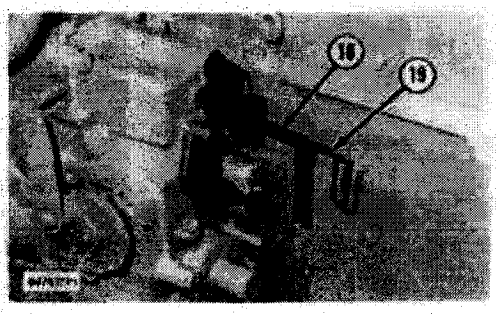
Checking Fuel Ratio Control Setting
(14) 6V7941 Compressor Assembly.

17. Turn the knob so the rod moves in 6V7941 Compressor Assembly (14) until the needles of the dial indicator move approximately 1 mm (one revolution of the large needle).

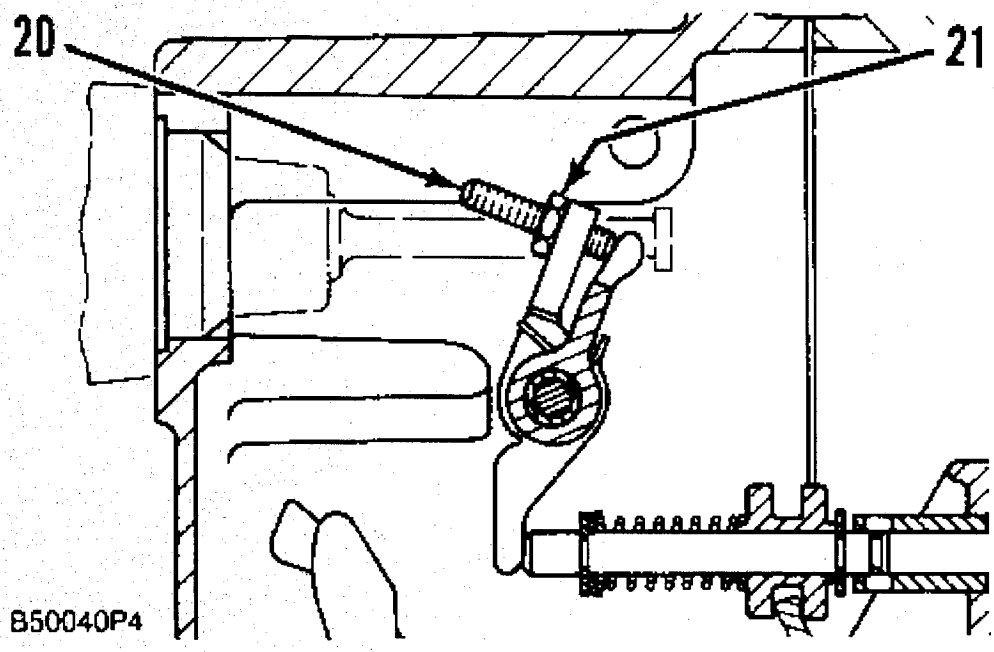
18. Slowly turn the knob to move the rod out of 6V7941 Compressor Assembly (14) until the needles of the dial indicator stop movement. This is the **Static** Fuel Ratio Control Lever Setting.

NOTE: When the rod is turned **out**, there may be a small initial movement of the dial indicator needles, then they will stop moving while the rod is turned out for approximately 11/2 turns more. Now the indicator needles will begin to move again, and will follow the turning of the knob until the setting is reached. It is important that the rod be turned slowly, so that fuel rack can follow the movement of the governor components.

19. See the TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche for the correct **Static** Fuel Ratio Control (lever) setting dimension, and compare it to the dial indicator reading. The dial indicator reading must be within ± .25 mm (.010 in) of the dimension given in the Fuel Setting And Related Information Fiche or an adjustment is needed.



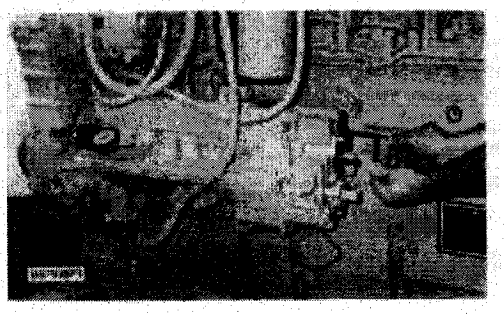
Tools For Linkage Adjustment
(18) 6V2105 Rack Adjusting Tool (outer part). (19) 6V2104 Hex Wrench.



Location Of Linkage Adjustment
(20) Adjustment screw. (21) Locknut.

20. If an adjustment is necessary, use 6V2105 Rack Adjusting Tool (18) to loosen the locknut (21) and then use the 6V2104 Hex Wrench (19) (part of the 6V2105 Rack Adjusting Tool) to turn the adjusting screw (20). Turn the screw **out** [counterclockwise (CCW)] to make the setting more positive, or **in** [clockwise (CW)] to make the setting more negative. Be sure to tighten the locknut after adjustment is complete. There is a zero tolerance for the linkage setting if an adjustment is made.

NOTE: The needles of the dial indicator will not follow the turning of the adjustment screw. It will be necessary to do Steps 15 through 17 until the adjustment is correct.

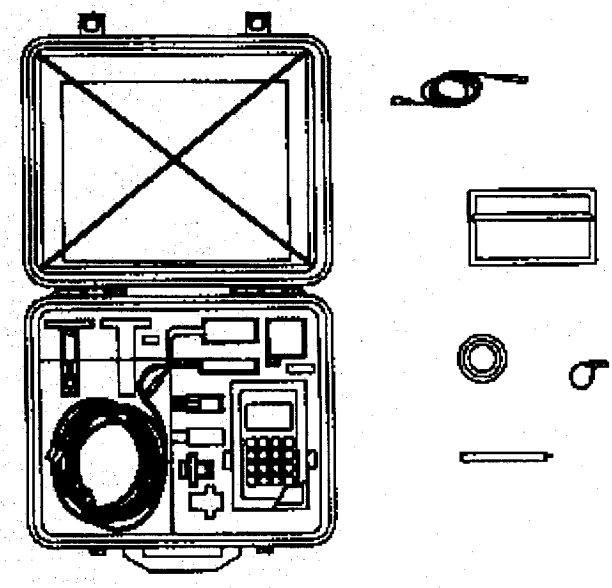


Adjustment Of Fuel Ratio Control Linkage

Engine Speed Measurement

Tools Needed		
9U7400	Multitach Group	1
6V4950	Injection Line Speed Pickup Group	1

1 Part of 9U7400 Multitach Group



9U7400 Multitach Group

The 9U7400 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.

Use the Operator's Manual, NEHS0605, for the operating instructions used for this tool.

The 6V4950 Injection Line Speed Pickup Group is another diagnostic tool accessory that can be used with the 6V2100 Multitach. It can be used on all Caterpillar Diesel Engines equipped with 6 mm (.25 in) single wall fuel injection lines. With this pickup group, engine speed can be measured quickly, automatically and with an accuracy of ± 1 rpm.

Special Instruction, SEHS8029 is with the group and gives instructions for use of the 6V4950 Injection Line Speed Pickup Group.

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 TMI (Technical Marketing Information) or 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:

Low Idle Adjustment
(1) Low idle stop screw.

1. To adjust the Low Idle rpm, start the engine and run with the governor control lever in the low idle position. Loosen the locknut for low idle screw (1). Turn the low idle screw to get the correct low idle rpm. Increase engine speed and return to low idle and check low idle speed again. Tighten the locknut.

Checking Set Point (Balance Point)

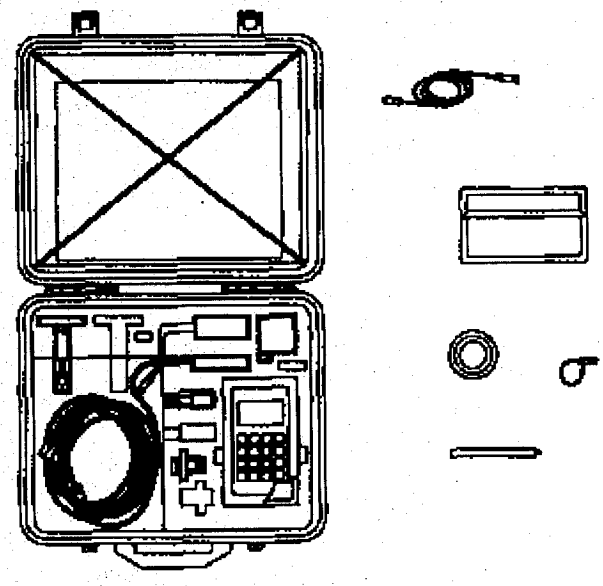
The engine set point is an adjusted specification and is important to the correct operation of the engine. High idle rpm is NOT an adjusted specification. Set point (formerly balance point) is full load rpm plus an additional 20 rpm. Set point is the rpm at which the fuel setting adjustment screw and 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		
9U7400	Multitach Group	1

The 9U7400 Multitach Group can be used to check the set point. Operators Manual NEHS0605 gives instructions for installation and use of this tool group.



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9U7400 Multitach Group

Alternate Method

Tools Needed		
8T0500	Circuit Tester	1
9U7400	Multitach Group	1

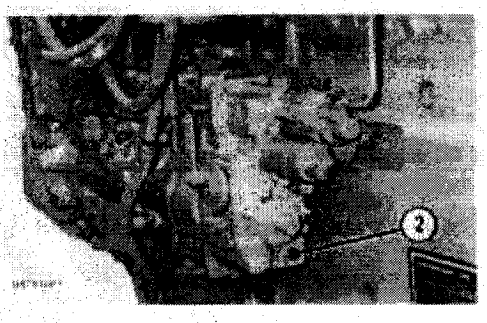
NOTE: Do not use the vehicle tachometer unless its accuracy is know to be within ± 1 rpm.

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 SEHS7050.

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



Terminal Location
(2) Brass terminal screw.

2. Connect the clip end of the 8T0500 Circuit Tester to the brass terminal screw (2) 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 6 and 7 with Full Load Speed from the Engine Information Plate. If the Engine Information Plate is not available, see the TMI (Technical Marketing Information) or 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 is 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: Engines will 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.

Remove Cover
(3) Cover.

2. If the set point rpm is not correct, remove cover (3).

Set Point Adjustment
(4) Locknut. (5) Adjustment screw.

3. Loosen locknut (4) and turn adjustment screw (5) 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.

Dash Pot Adjustment

Adjustment Of Dash Pot
(1) Needle Valve.

This adjustment controls the amount of restriction to oil flow into and out of the dash pot chamber. Too much oil flow will cause the governor to hunt, and too little oil flow will cause a slow governor action.

1. Turn needle valve (1) in (clockwise) until it stops. Now, open needle valve (1) two full turns (counterclockwise). The exact point of adjustment is where the governor gives the best performance.

NOTE: Do not keep needle valve (1) fully closed. This can cause excessive overshoot on start up or load rejection.

2. Check governor operation.

With the engine running at medium (mid) speed, load the engine (at least one-quarter load) to find the stability of the setting. Quickly remove the load. A slight overshoot of speed is desired, as it reduces response time. The engine speed should return to smooth steady operation. If it does not have a slight overshoot and return to a smooth steady operation, adjust the needle valve and repeat the above procedure.

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 6.23 kPa (25 inches of H_2O).

Back pressure from the exhaust (pressure difference measurement between exhaust at outlet elbow and atmospheric air) must not be more than 9.96 kPa (40 inches of H_2O).

Measurement Of Pressure In Inlet Manifold

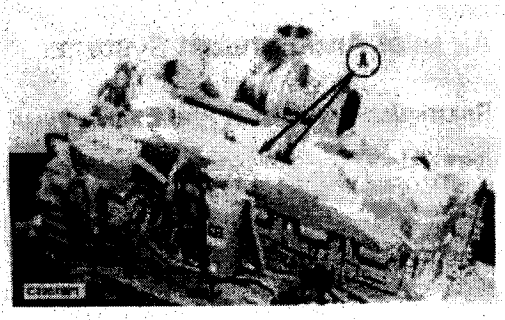
Tools Needed		
1U5470	Engine Pressure Group	1

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 TMI (Technical Marketing Information) or 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 TMI (Technical Marketing Information) or Fuel Setting And Related Information Fiche. Development of this information is done with these conditions:

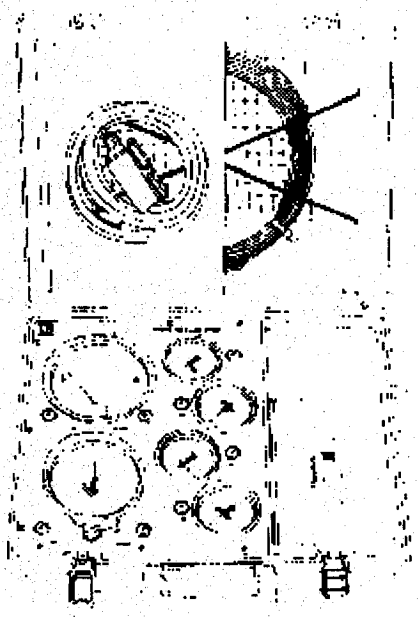
a. 99 kPa (29.7 inches of Hg) barometric pressure.
b. 29°C (85°F) outside air temperature.
c. 35 API rated fuel.

On a turbocharged and aftercooled engine, a change 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 TMI (Technical Marketing Information) or 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 or exhaust does not have a restriction when making a check of pressure in the inlet manifold.**



Pressure Test Location
(A) Plugs (1/4 inch NPT).

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



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1U5470 Engine Pressure Group

This tool group has a indicator to read pressure in the inlet manifold. Special Instruction, SEHS8907 is with the tool group and gives instructions for its use.

Exhaust Temperature

Tools Needed		
123-6700	Infrared Thermometer II	1

Use the 123-6700 Infrared Thermometer II to check exhaust temperature. The Operator's Manual, NEHS0630, for the 123-6700 Infrared Thermometer II gives complete operating and maintenance instructions for this tool.

Air-To-Air Aftercooled Systems

Tools Needed		
FT1984	Air-To-Air Aftercooler Testing Group	1
FT1438	Dynamometer Testing Aftercooler	1

Visual Inspection

Inspect all air lines, hoses and gasket connections at each oil change. Make sure the constant torque hose clamps are tightened to the correct torque. Check the truck manufacturer's specifications for the correct torque. Check welded joints for cracks and make sure all brackets are tightened in position and are in good condition. Use compressed air to clean cooler core blockage caused by debris or dust. Inspect the cooler core fins for damage, debris or salt corrosion. Use a stainless steel brush with soap and water to remove corrosion.

⚠ WARNING

Pressure air can cause personal injury.

When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

NOTE: When air to air aftercooler system parts are repaired and/or replaced, a leak test is recommended.

The use of winter fronts or shutters is discouraged with air to air aftercooled systems. Winter fronts can only be used on truck models where tests have shown that the engine jacket water will overheat before the inlet manifold air temperature is excessive. On these trucks, sensors and indicators or alarms are installed to indicate engine operating conditions before excessive inlet manifold air temperatures are reached. Check with the truck manufacturer on winter front and shutter application.

Air System Restriction

Pressure measurements should be taken at the turbocharger outlet and inlet manifold. When the total pressure drop of the charged air system at maximum air flow exceeds the following limits, the air lines and cooler core must be inspected for internal restriction and cleaned, repaired or replaced as necessary.

Air Cooling System Maximum Pressure Drop	
Engine	**Pressure Drop**
8PN1409-UP (425 Hp)	15.2 kPa (61 inches of H_2O)
All Others	13.4 kPa (54 inches of H_2O)

Turbocharger Failure

⚠ WARNING

Pressure air can cause personal injury.

When using pressure air for cleaning, wear a protective face shield, protective clothing and protective shoes.

The maximum air pressure must be below 205 kPa (30 psi) for cleaning purposes.

If a turbocharger failure occurs, remove the air to air cooler core and flush internally with a solvent that removes oil and other foreign substances. Shake cooler to eliminate any trapped debris. Wash with hot, soapy water; rinse thoroughly with clean water; and blow dry with compressed air in reverse direction of normal air flow. Carefully inspect the system to make sure it is clean.

NOTICE

Do not use caustic cleaners or damage to the aftercooler core will result.

Inlet Manifold Pressure

Normal inlet manifold pressure with high exhaust temperature can be caused by cooler core fin blockage. Clean the cooler core fins, see Visual Inspection for the cleaning procedure to use.

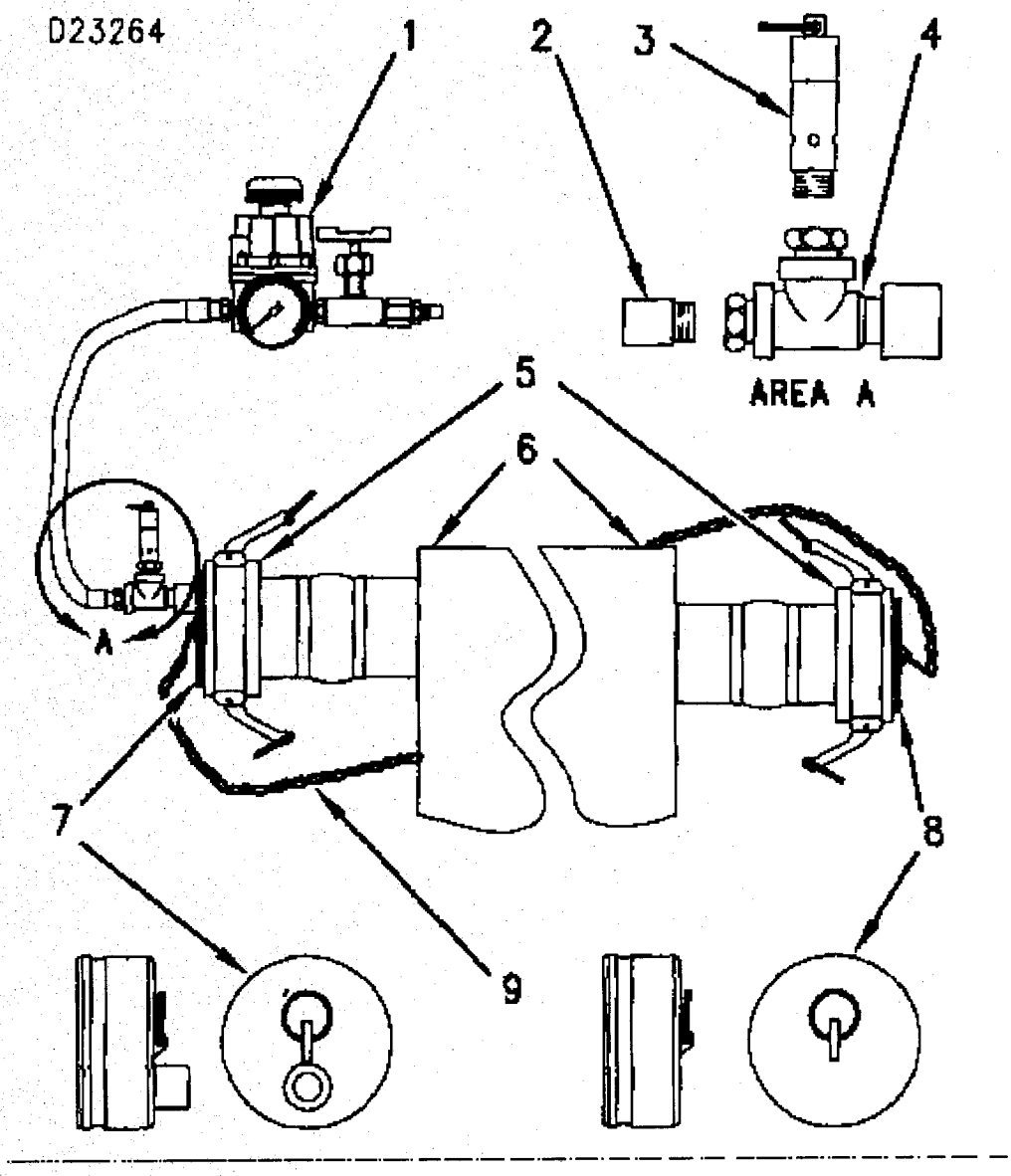
Low inlet manifold pressure and high exhaust manifold temperature can be caused by any of the conditions that follow:

1. A plugged air cleaner. Clean or replace the air cleaner as needed.
2. A blockage in the air lines between the air cleaner and turbocharger.

All restrictions must be removed.

3. Cooler core leakage. Pressure test the cooler core, see Aftercooler Core Leakage for the correct procedure to use and repair or replace parts as needed.
4. Leakage from the pressure side of the induction system. Check and repair leaks.
5. Inlet manifold leak. Check for loose, missing and damaged fittings or plugs. Also check the manifold to cylinder head gaskets.

Aftercooler Core Leakage



Using FT1984 Air-To-Air Aftercooler Test Group
(1) Regulator and valve assembly. (2) Nipple. (3) Relief valve. (4) Tee. (5) Coupler. (6) Aftercooler. (7) Dust Plug. (8) Dust plug. (9) Chain.

A low power problem in the engine can be the result of aftercooler leakage. Low power, low boost pressure, black smoke, and/or high exhaust temperature can be the result of an aftercooler system leakage.

NOTICE

Remove all air leaks from the system to prevent engine damage. In some operating conditions, the engine can pull a manifold vacuum for

short periods of time. A leak in the aftercooler or air lines can let dirt and other foreign material into the engine and cause rapid wear and/or damage to engine parts.

A large cooler core leak often can be found by making a visual inspection. To check for smaller leaks, use the following procedure:

1. Disconnect the air pipes from the inlet and outlet side of the aftercooler core.

2. Install couplers (5) and dust plugs (7) & (8) from the FT1984 Air-to-Air Aftercooler Test Group as shown on each side of the aftercooler core. Installation of additional hose clamps on hump hoses is recommended to prevent the hoses from bulging while the aftercooler core is being pressurized.

⚠ WARNING

Dust plug chains (9) must be installed to the aftercooler core or the radiator brackets to prevent possible injury while testing. Do not stand in front of the dust plugs while testing.

---

3. Install regulator and valve assembly (1) on the outlet side of the aftercooler. Attach air supply.

NOTICE

Do not use more than 240 kPa (35 psi) air pressure or damage to the aftercooler core can be the result.

---

4. Open air valve and pressurize the aftercooler to 205 kPa (30 psi). Shut off air supply.

5. Inspect all connections for air leakage.

6. System pressure should not drop more than 35 kPa (5 psi) in 15 seconds.

7. If the pressure drop is more than specified, use a solution of soap and water to check all areas of possible leakage and look for air bubbles. Replace hoses or repair the aftercooler core as needed.

⚠ WARNING

To help prevent personal injury when the tooling is removed, relieve all pressure in the system slowly by using air regulator and valve assembly (1).

8. After testing, remove FT Tooling and connect air pipes on each side of the aftercooler.

Dynamometer Test

Air to air aftercooled chassis dynamometer tests, in hot ambient temperatures, can add a greater heat load to the jacket water cooling system, therefore the jacket water cooling system temperature must be monitored. Also, monitor the inlet air temperature as it may need a power correction factor along with fuel API, fuel temperature and barometric pressure.

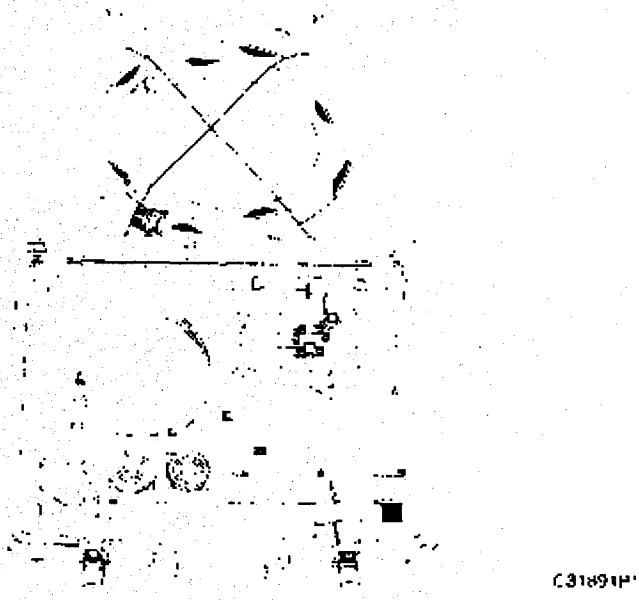
NOTE: Refer to special instructions Truck Performance Diagnostic Guide, SEBD0808 and Using The Caterpillar Performance Analysis Report (PAR) Program For On-Highway Truck Engines, SEHS8025 for more detailed instructions concerning preparation of the truck, proper use of the dynamometer and use of the Technical Information File microfiche.

For engine dynamometer tests, use the FT1438 Dynamometer Testing Aftercooler. FT1438 provides an air to water aftercooler to control the inlet air temperature to 43°C (110°F).

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, SEHS8712.

Compression

An engine that runs rough can have a leak at the valves, or have valves that need adjustment. 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 is a one piece casting with two inlet and two exhaust valves per cylinder. The cylinder head has valve seat inserts (one insert has an integral air deflector), valve guides and bridge dowels that can be removed when they are worn or have damage. Replacement of these components can be made with the tools that follow.

NOTE: One inlet insert has a lip which has to be installed at a predetermined angle, make sure the correct angle is obtained before installation.

Valves

Valve removal and installation is easier with use of the 5S1330 Valve Spring Compressor Assembly and 5S1322 Valve Keeper Inserter.

Valve Seat Inserts

Valve seat inserts can be removed and installed. For easier installation, lower the temperature of the insert before it is installed in the head.

Valve Guides

Valve guides can be removed and installed. 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, SMHS7526 gives an explanation for this procedure. Grind the valves after the new valve guides are installed.

Checking Valve Guide Bores

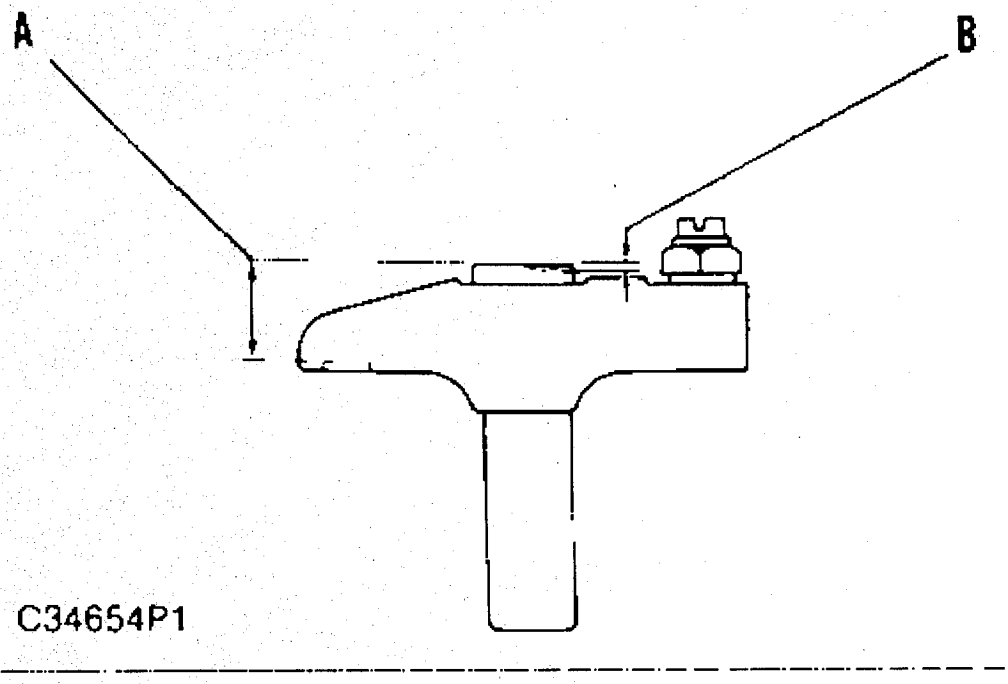
Use the 5P3536 Valve Guide Gauge Group to check the bore of the valve guides. Special Instruction, GMG02562 gives complete and detailed instructions for use of the 5P3536 Valve Guide Gauge Group.

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. To check for wear use a dial indicator to measure the amount of wear on the bridge seat. Make sure the contact point on the dial indicator is small enough in diameter to get an accurate measurement.



Dimensions For Reconditioning Bridge Seat
(A) Minimum dimension after reconditioning ... 16.51 mm (.650 in). (B) Allowable wear before reconditioning ... 0.13 mm (.005 in).

Use the bridge again if the wear is 0.13 mm (.005 in) or less. When the wear seat is worn more than the allowable limit, the worn surface of the seat can be ground flat. The maximum amount of material that can be removed is 0.38 mm (.015 in). If the seat cannot be made flat, replace the bridge. Reconditioning of the wear seat can only be done once.

Use the procedure that follows to make an adjustment to the bridge.

NOTE: Valves must be fully closed.

Bridge Adjustment

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 30 ± 4 N·m (22 ± 3 lb ft).

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

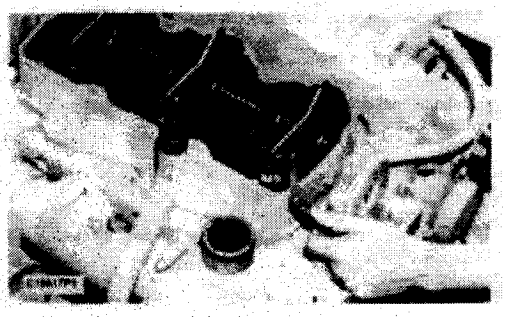
Valve Lash Setting

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

Valve Lash Check: Engine Stopped	
Exhaust	0.69 to 0.84 mm (.027 to .033 in)
Inlet	0.30 to 0.46 mm (.012 to .018 in)

NOTE: When the valve lash is checked, adjustment is **not necessary** if the measurement is in the range given in the chart for Valve Lash Check: Engine Stopped. If the measurement is outside this range, adjustment is necessary. See the chart for Valve Lash Setting: Engine Stopped, and make the setting to the nominal (desired) specifications in this chart.

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



Valve Lash Check

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:

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

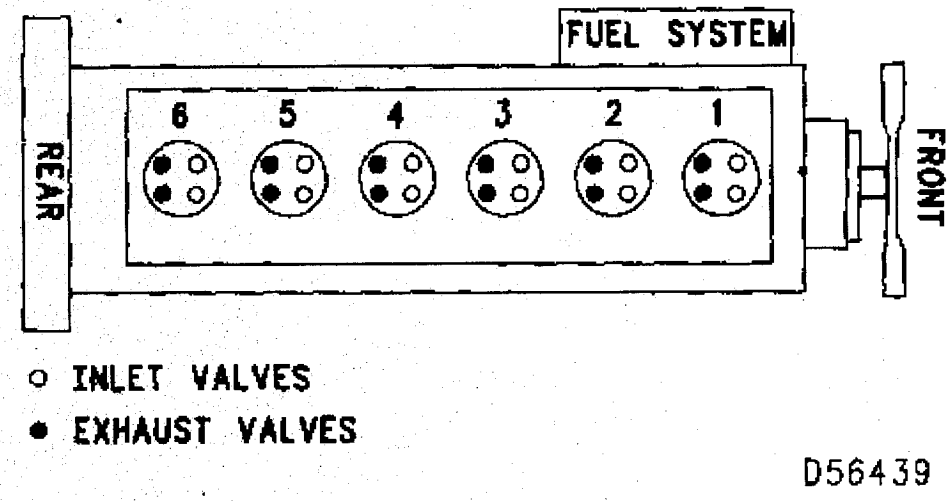
Valve Adjustment

3. After each adjustment, tighten the nut for valve adjustment screw to 30 ± 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 inlet valves for cylinders 3, 5, and 6. Make an adjustment to the valve lash on the exhaust valves for cylinders 2, 4, and 6.

6. Remove the timing bolt from the flywheel when all adjustments to the valve lash have been made.



Cylinder And Valve Location

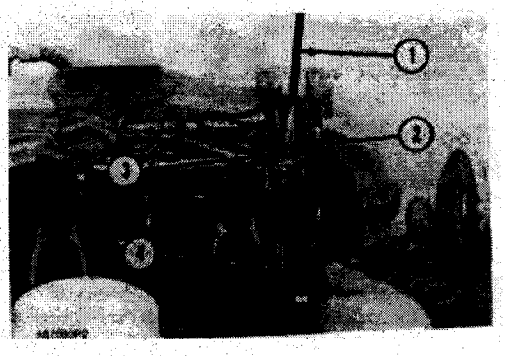
Jake Brake Adjustment

NOTE: Slave piston lash is measured between the slave piston (both ends of the yoke) and the bridge.

Slave Piston Lash Setting	
Brake Model	**Lash Setting**
346B	1.78 mm (.070 in)
346C	2.03 mm (.080 in)
346D	1.70 mm (.067 in)

On any model not shown, see specifications on the brake serial number plate.

Use the procedure that follows to make the adjustment:



Slave Piston Lash Adjustment (Typical Example)
(1) Screwdriver. (2) Adjustment screw. (3) Locknut. (4) Feeler indicators.

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. Loosen locknut (3). With screwdriver (1), turn adjustment screw (2) to make correct adjustment for cylinders 1, 3, and 5.

3. After each adjustment, tighten locknut (3) to a torque of 22 N·m (16 lb ft) and check the slave piston lash again.

NOTE: Be sure to check the lash with two feeler indicators (4) at the same time (one under each side of slave piston).

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 slave piston lash for cylinders 2, 4, and 6.

6. Remove the timing bolt from the flywheel when all adjustments have been made.

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 at 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.

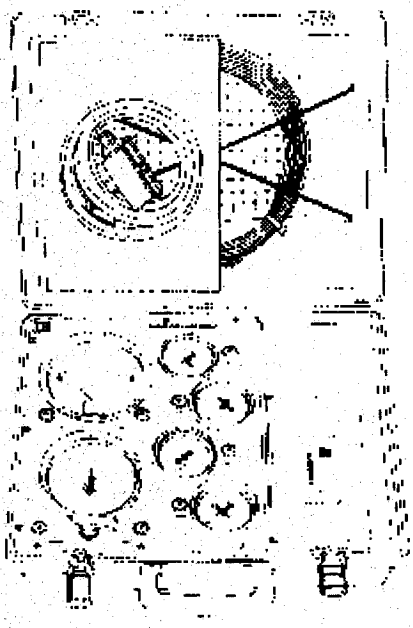
Too much oil consumption can also be the result if oil with the wrong viscosity is used. Oil with a thin viscosity can be caused by fuel leakage into the crankcase, or by increased engine temperature.

Measuring Engine Oil Pressure

Tools Needed		
1U5470	Engine Pressure Group	1

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

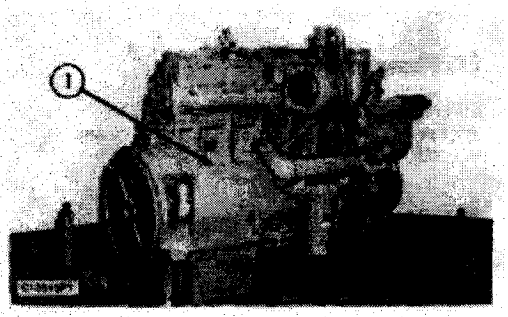
The 1U5470 Engine Pressure Group can be used to check engine oil pressure.



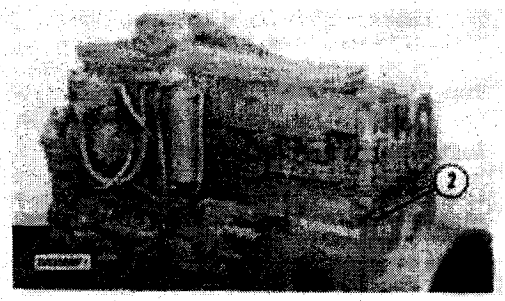
1U5470 Engine Pressure Group

This tool group has a indicator to read oil pressure in the engine. Special Instruction, 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 oil. If any other viscosity of oil is used, the information in the Engine Oil Pressure Graph does not apply.



Oil Manifold (Right Side Of Engine)
(1) Pressure test location.



Oil Pressure Indicator Connection (Left Side Of Engine)
(2) Pressure test location.

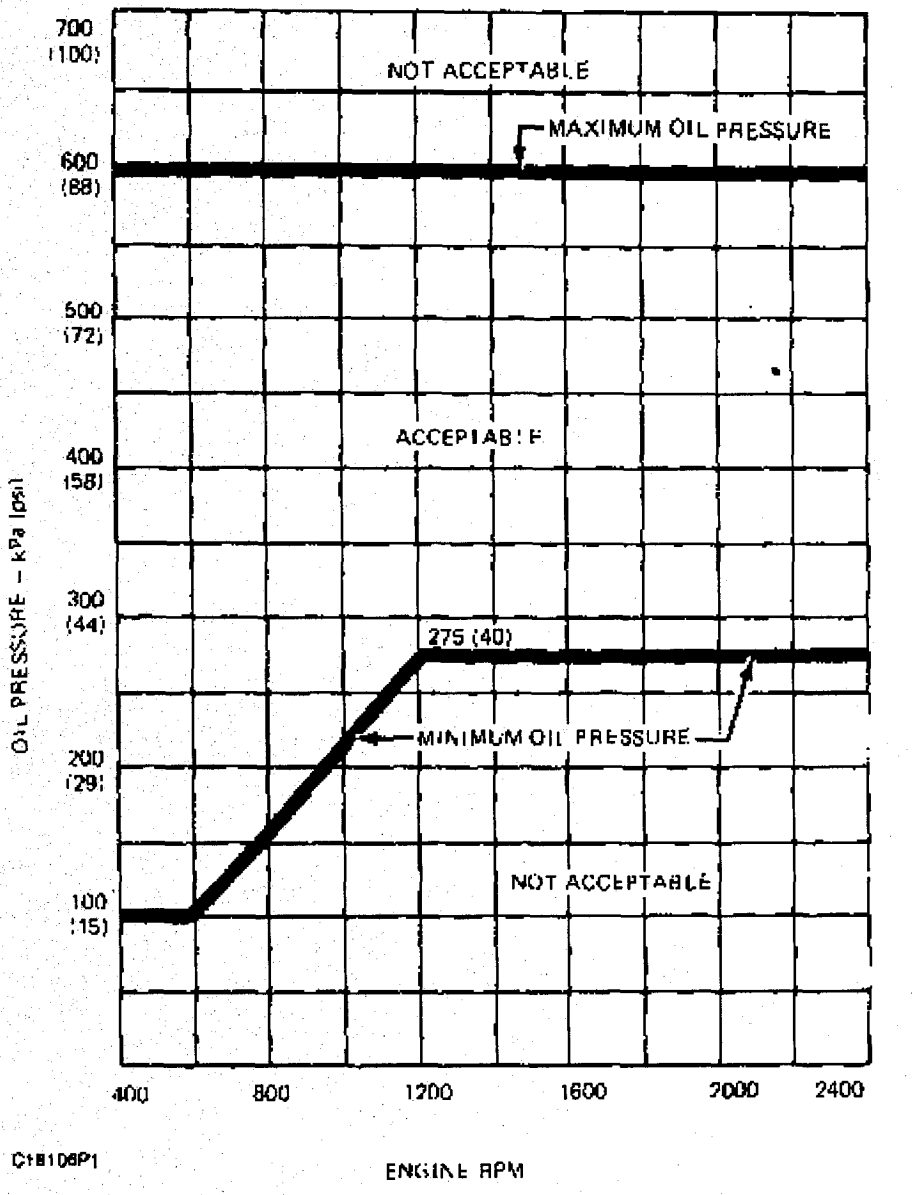
2. Connect the 1U5470 Engine Pressure Group to the main oil manifold at pressure test location (1) or pressure test location (2).

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

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

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 or 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 engine oil pump supply tube. This will cause the engine oil pump to not have the ability to supply enough lubrication to the engine components.

Engine Oil Pump Does Not Work Correctly

The inlet screen of the supply tube for the engine 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 engine oil pump will also cause cavitation and loss of oil pressure. If the bypass valve for the engine oil pump is held in the open (unseated) position, the lubrication system can not get to a maximum pressure. Engine oil pump gears that have too much wear will cause a reduction in oil pressure.

Engine Oil Filter Bypass Valves

If the bypass valve for the engine oil filter is held in the open position (unseated) because the engine 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 engine 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 Jets

When the engine is operated, piston 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 piston cooling jets, or it is bent in the wrong direction, seizure of the piston will be caused in a very short time.

To eliminate the possibility of damaging piston cooling jets during removal of the connecting rod cap, the piston cooling jet assembly should always be removed. The wider connecting rod cap design, cannot be removed without damaging the "double tube" piston cooling jet design.

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

NOTE: This tool group does not currently accommodate the "double tube" piston cooling jet design.

Oil Pressure Is High

Oil pressure will be high if the bypass valve for the engine 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.

If the indicator 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 passages of the engine oil cooler. If the engine 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 engine oil cooler has a restriction.

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

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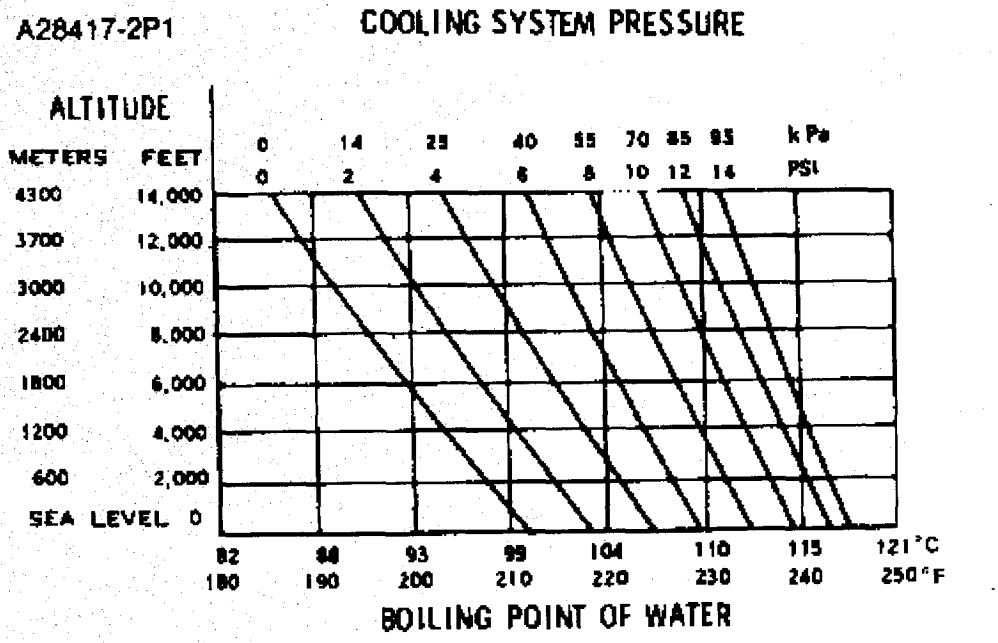
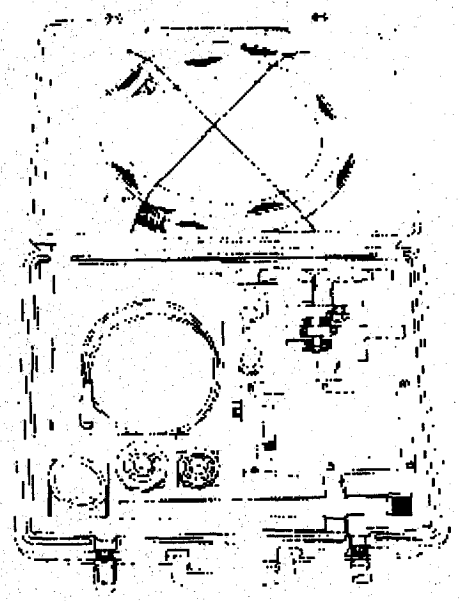


Test Tools for Cooling System

Tools Needed		
4C6500	Digital Thermometer Group	1
8T2700	Blowby/Air Flow Indicator Group	1
9U7400	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 over cooling (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, NEHS0554.



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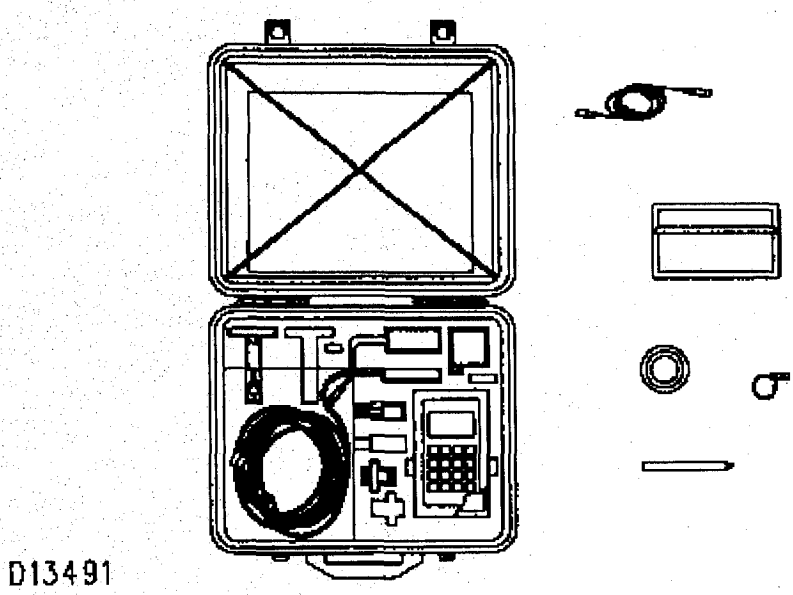
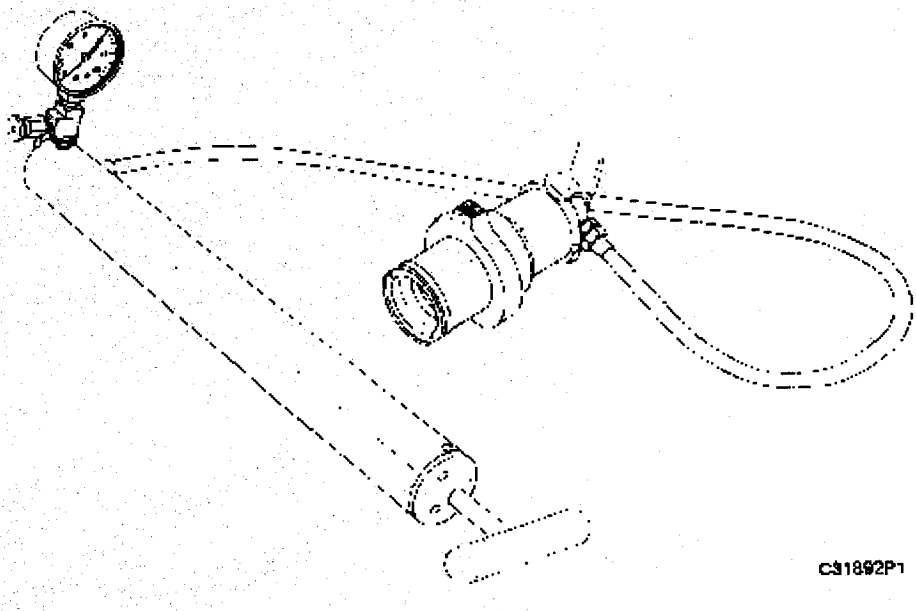
8T2700 Blowby/Air Flow Indicator Group

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, SEHS8712.



9U7400 Multitach Group

The 9U7400 Multitach Group is used to check the fan speed. The Operator's Manual, NEHS0605, for the operating instructions for this tool.



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.

Checking Pressure Cap

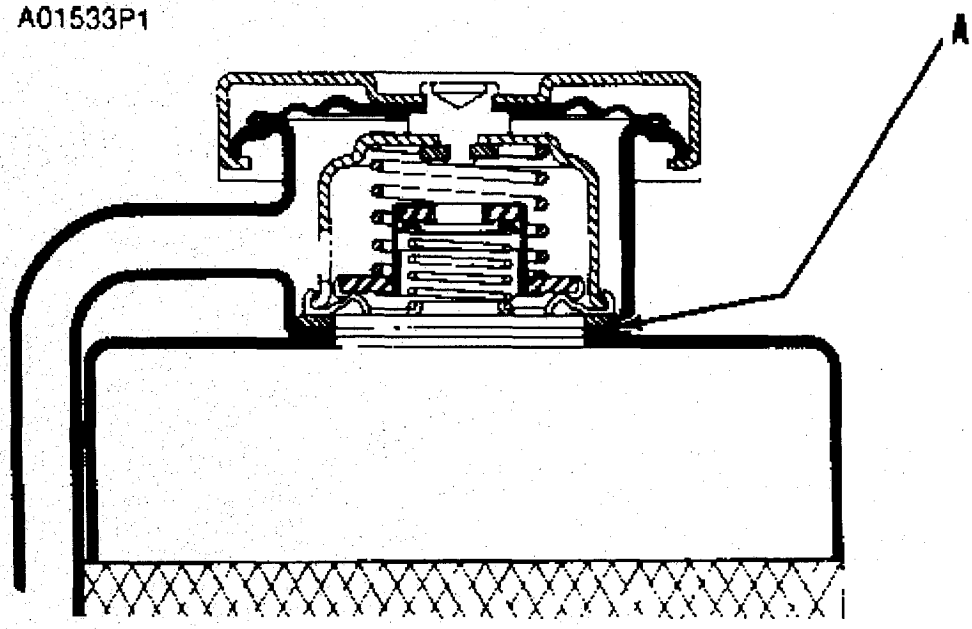
Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

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.



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 indicator for the exact pressure that makes the pressure cap open.

4. Make a comparison of the reading on the indicator 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 indicator 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 indicator is still the same after 5 minutes, the radiator and cooling system does not have leakage. If the reading on the indicator goes down and you do not see any outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary.

Indicator For Water Temperature

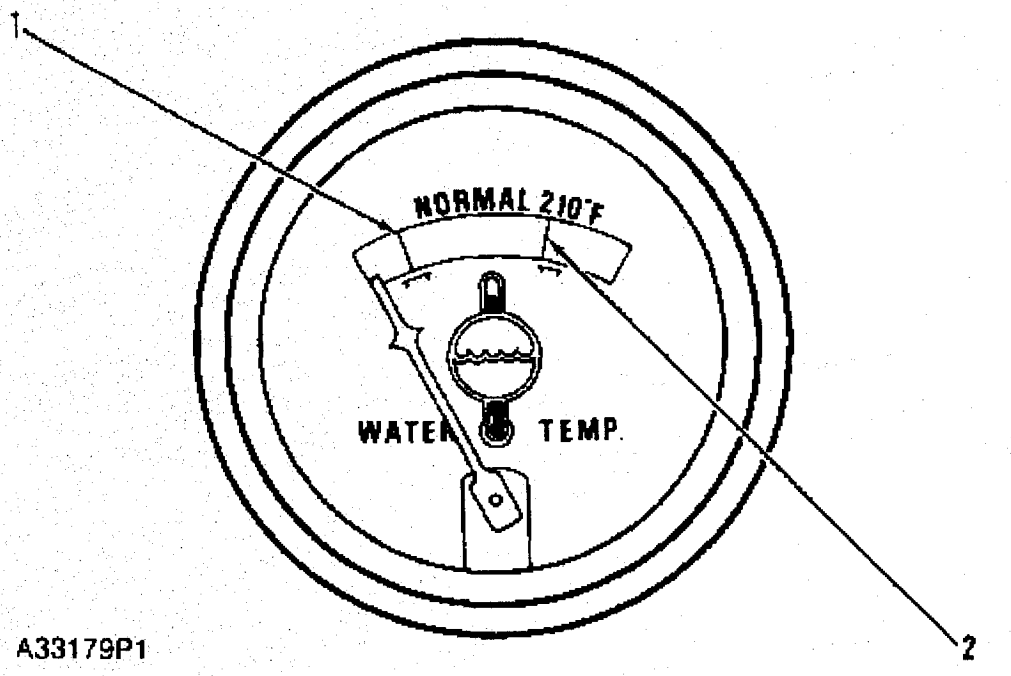
Tools Needed		
4C6500	Digital Thermometer Group	1

4C6500 Digital Thermometer Group

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 indicator for water temperature shows that the engine is getting too hot, look for coolant leakage. If a place can not be found where there is coolant leakage check the accuracy of the indicator for water temperature. A temperature indicator of known accuracy can be used to make this check. Also, the 4C6500 Digital Thermometer Group may 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 Indicator

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

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

Water Temperature Regulators

1. Remove the regulator from the engine.

2. Heat water in a pan until the temperature is 98°C (208°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 10.4 mm (.41 in).

6. If the distance is less than 10.4 mm (.41 in), make a replacement of the regulator.

Belt Tension Chart

BELT TENSION CHART

BELT SIZE	WIDTH BELT TOP		GAUGE READING				BORROUGHS GAUGE NUMBER	
			BELT TENSION "INITIAL"*		BELT TENSION "USED"**		OLD GAUGE NUMBER	NEW GAUGE NUMBE
	MM	IN	N	LB	N	LB		
3/8	10.72	0.422	445+/-22	100+/-5	400+/-22	90+/-5	BT-33-95	BT-33-97
1/2	13.89	0.547	534+/-22	120+/-5	400+/-44	90+/-10	BT-33-95	BT-33-97
5V	15.88	0.626	534+/-22	120+/-5	400+/-44	90+/-10	BT-33-72	BT-33-72C
11/16	17.48	0.688	534+/-22	120+/-5	400+/-44	90+/-10	BT-33-72	BT-33-72C
3/4	19.05	0.750	534+/-22	120+/-5	400+/-44	90+/-10	BT-33-72	BT-33-72C
15/16	23.83	0.983	534+/-22	120+/-5	400+/-44	90+/-10	BT-33-72	BT-33-77
8K	27.92	1.099	800+/-22	180+/-5	489+/-44	110+/-10	--------	BT-33-109
6PK	20.94	0.824	667+/-22	150+/-5	487+/-44	105+/-10	--------	BT-33-109

MEASURE TENSION OF BELT FARTHEST FROM ENGINE

* BELT TENSION "INITIAL" is for a new belt.

** BELT TENSION "USED" is for a belt with over 30 minutes of operation at rated speed.

DQ159

Basic Block

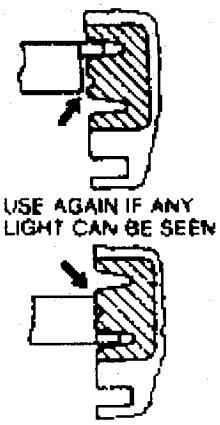
Piston Rings

This engine has piston grooves and rings of the KEYSTONE (taper) design. The 1U6431 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.

1U6431 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, 1603	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
5.4"	3406B Truck (1985-UP)	G	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 1U6431 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 nuts in the step sequence that follows:

1. Put 4C5593 Thread Lubricant on bolt threads and contact surfaces of nut and cap.

2. Tighten all nuts to 90 ± 8 N·m (66 ± 6 lb ft).

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

4. Tighten each nut 90 degrees ± 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.

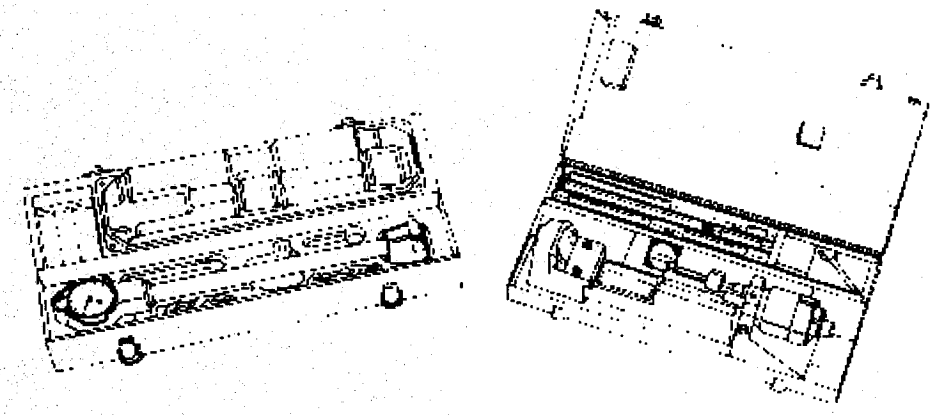
Connecting Rod And Main Bearings

Connecting rod bearings are available with 0.63 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 0.63 mm (.025 in) larger outside diameter than the original size bearings.

Cylinder Block

Tools Needed		
1P3537	Dial Bore Indicator Group	1



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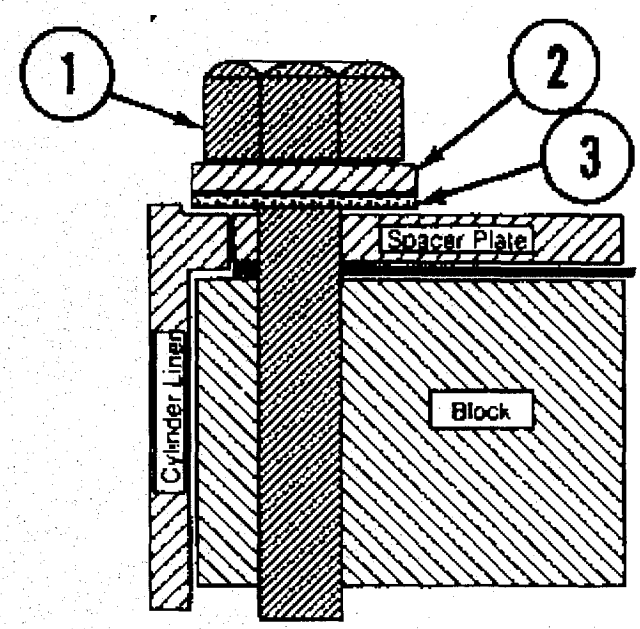
1P3537 Dial Bore Indicator Group

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, SMHS7606 gives instructions for the use of 1P4000 Line Boring Tool Group for alignment of the main bearing bores. The 1P3537 Dial Bore Indicator Group can be used to check the size of the bores. Special Instruction, GMG00981 is with the group.

Cylinder Liner Projection

NOTE: This procedure alleviates the need for the "H" bar to hold down liners during projection measurements.

Tools Needed		
8T0455	Liner Projection Tool Group	1



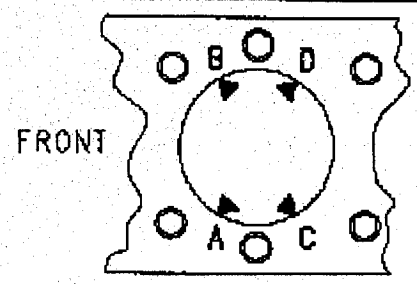
Liner Projection Components
(1) Bolt. (2) Washer. (3) Washer.

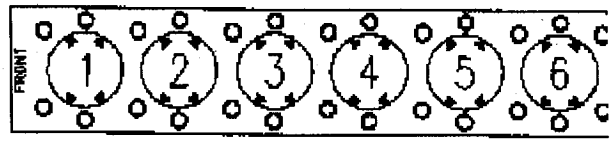
Components Needed				
Item	Part No.	Description	Quantity For One Cylinder	Quantity For Six Cylinders
1	7H3598	Bolt	6	26
2	8F1484	Washer	6	26
3	7K1977[1]	Washer	6	26

1 These are fabric material washers, an expendable item, therefore you may wish to order more than the amount indicated.

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

Date _____ Miles, Km Hours _____ Engine Serial Number _____ Vehicle Serial Number _____





Liner Projection
Max 0.15 mm (.006 in)
Min 0.03 mm (.001 in)

1A	
1B	
1C	
1D	
SUM 1	
AVG 1	
2A	
2B	
2C	
2D	
SUM 2	
AVG 2	
3A	
3B	
3C	
3D	
SUM 3	
AVG 3	
4A	
4B	
4C	
14D	
SUM 4	
AVG 4	
5A	
5B	
5C	
5D	
SUM 5	
AVG 5	
6A	
6B	
6C	
6D	
SUM 6	
AVG 6	

Max Variation Each Cylinder
Max 0.051 mm (.002 in)

Max 1A-1D	
Min 1A-1D	
Variation	
Max 2A-2D	
Min 2A-2D	
Variation	
Max 3A-3D	
Min 3A-3D	
Variation	
Max 4A-4D	
Min 4A-4D	
Variation	
Max 5A-5D	
Min 5A-5D	
Variation	
Max 6A-6D	
Min 6A-6D	
Variation	

Max Variation of AVG Between Adjacent Liners
Max 0.051 mm (.002 in)

AVG 1	
AVG 2	
Variation	
AVG 2	
AVG 3	
Variation	
AVG 3	
AVG 4	
Variation	
AVG 4	
AVG 5	
Variation	
AVG 5	
AVG 6	
Variation	

Max Variation of AVG Un One Cylinder Head
Max 0.102 mm (.004 in)

Max AVG 1-6	
Min AVG 1-6	
Variation	

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

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.

Specifications	
Liner Projection	0.025 to 0.152 mm (0.0010 to 0.0060 in)
Maximum Variation In Each Liner	0.051 mm (0.0020 in)
Maximum Average Variation Between Adjacent Liners	0.051 mm (0.0020 in)
Maximum Variation Between All Liners	0.102 mm (0.0040 in)

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.

If the liner projections are all below the specifications or low in the range, 0.025 mm (0.0010 in) or 0.051 mm (0.0020 in), try using a thinner spacer plate (6I3189 or 6I4303). These plates are 0.076 mm (0.0030 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 (0.0030 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 (0.0030 in).

Do not exceed the maximum liner projection of 0.152 mm (0.0060 in). Excessive liner projection will contribute to liner flange cracking.

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

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

NOTE: Apply clean engine oil immediately before assembly. If applied to early, the seals may swell and be pinched under the liners during installation.

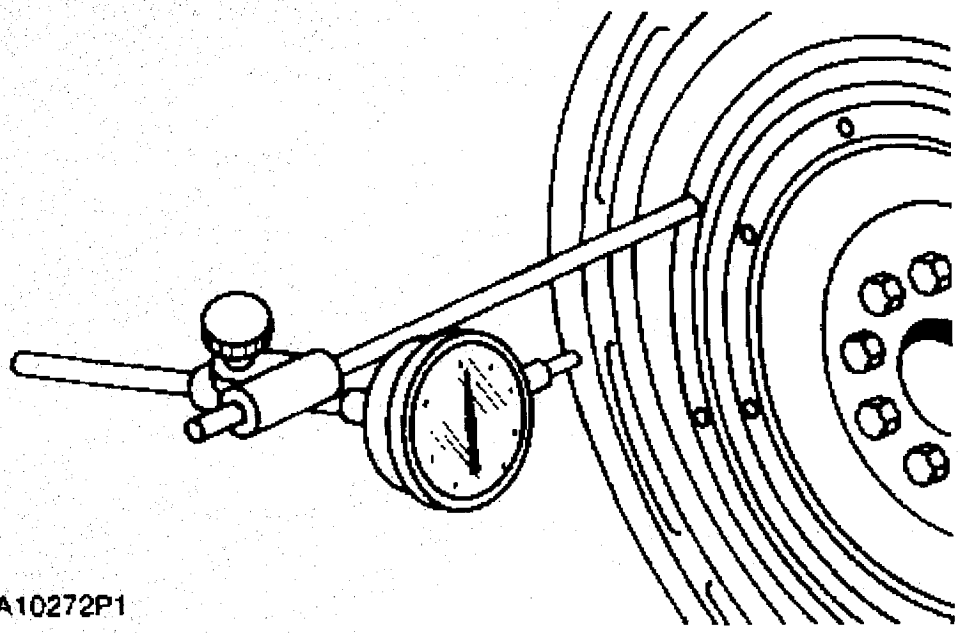
Flywheel And Flywheel Housing

Tools Needed		
8T5096	Dial Indicator Group	1

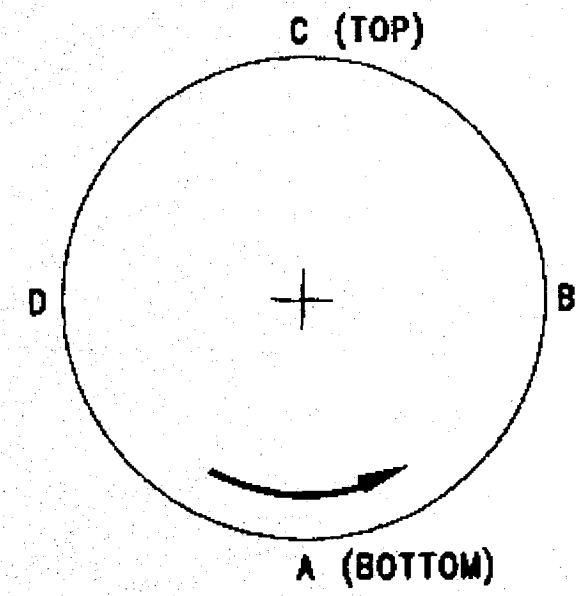
Heat the ring gear to install it. Do not heat to more than 315°C (600°F). Install the ring gear so the chamfer on the gear teeth are next to the starter pinion when the flywheel is installed.

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



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

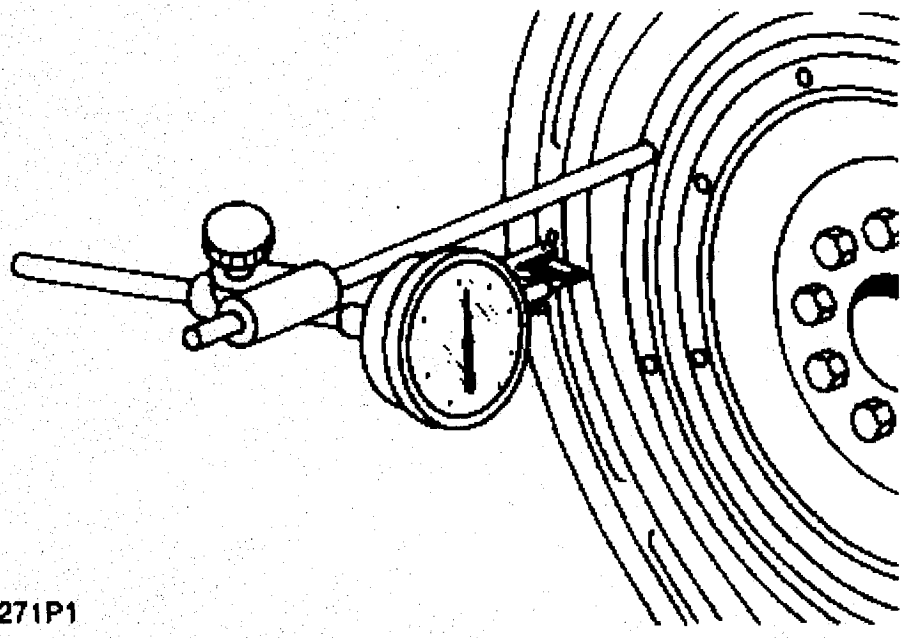
1. Fasten a dial indicator to the crankshaft flange so the anvil of the indicator will touch the face of the flywheel housing.

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

3. With dial indicator set at 0.0 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 run out (axial eccentricity) of the flywheel housing.

Bore Runout (Radial Eccentricity) Of The Flywheel Housing



8T5096 Dial Indicator Group Installed

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

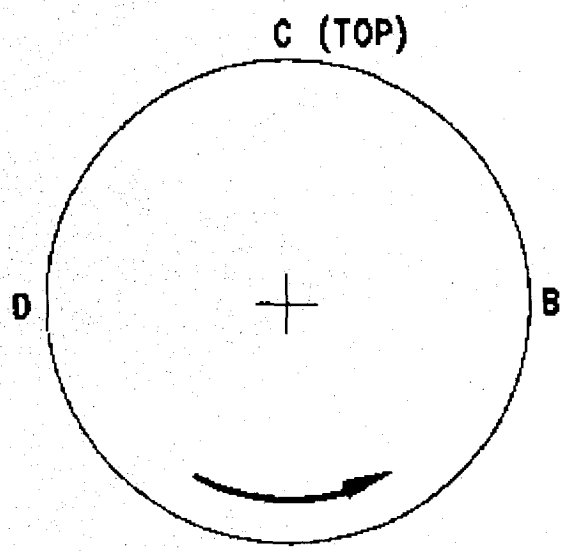
2. With the dial indicator in position at (C), adjust the dial indicator to "0" (zero). Push the crankshaft up against the top of the bearing. Write the measurement for bearing clearance on line 1 in column (C) in the chart for dial indicator measurements.

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 I 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 measurements in the chart.



Checking Bore Runout Of The Flywheel Housing

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.

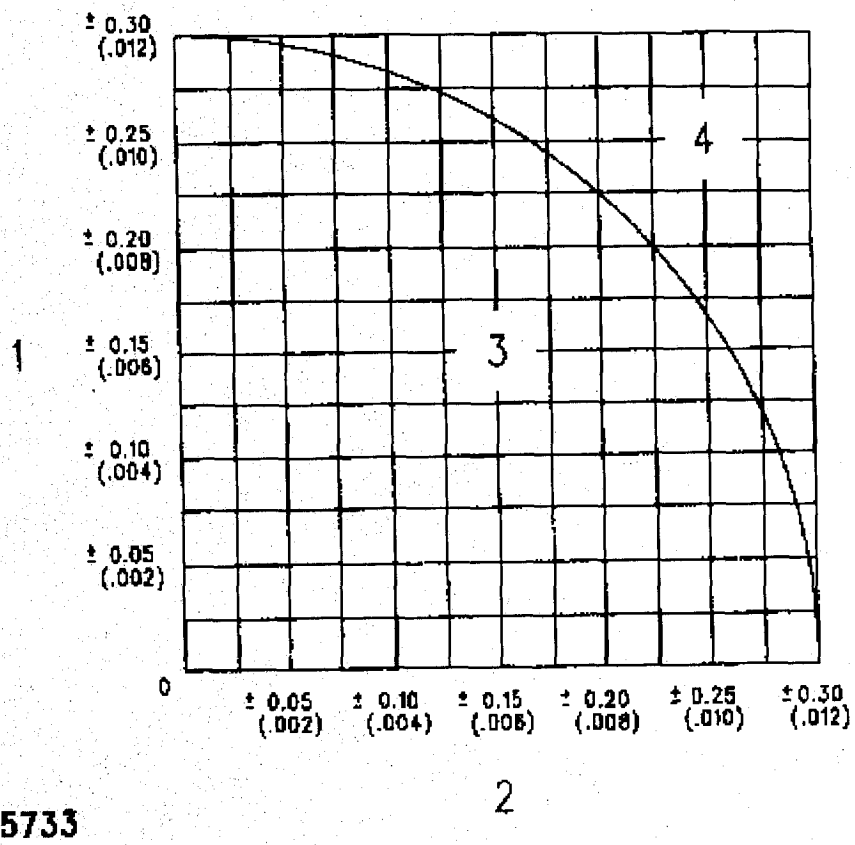
D15721

8. Add lines I and 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.

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

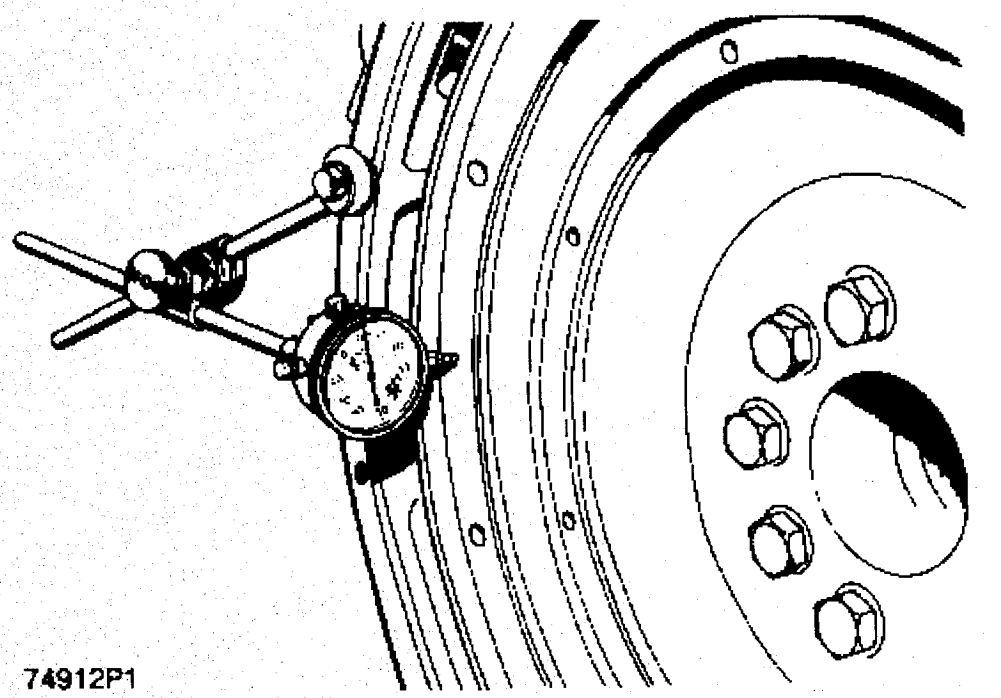
11. If the point of intersection is in the range marked "Acceptable" the bore is in alignment. If the point of intersection is in the ranged marked "Not Acceptable" the flywheel housing must be changed.



Graph For Total Eccentricity

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.



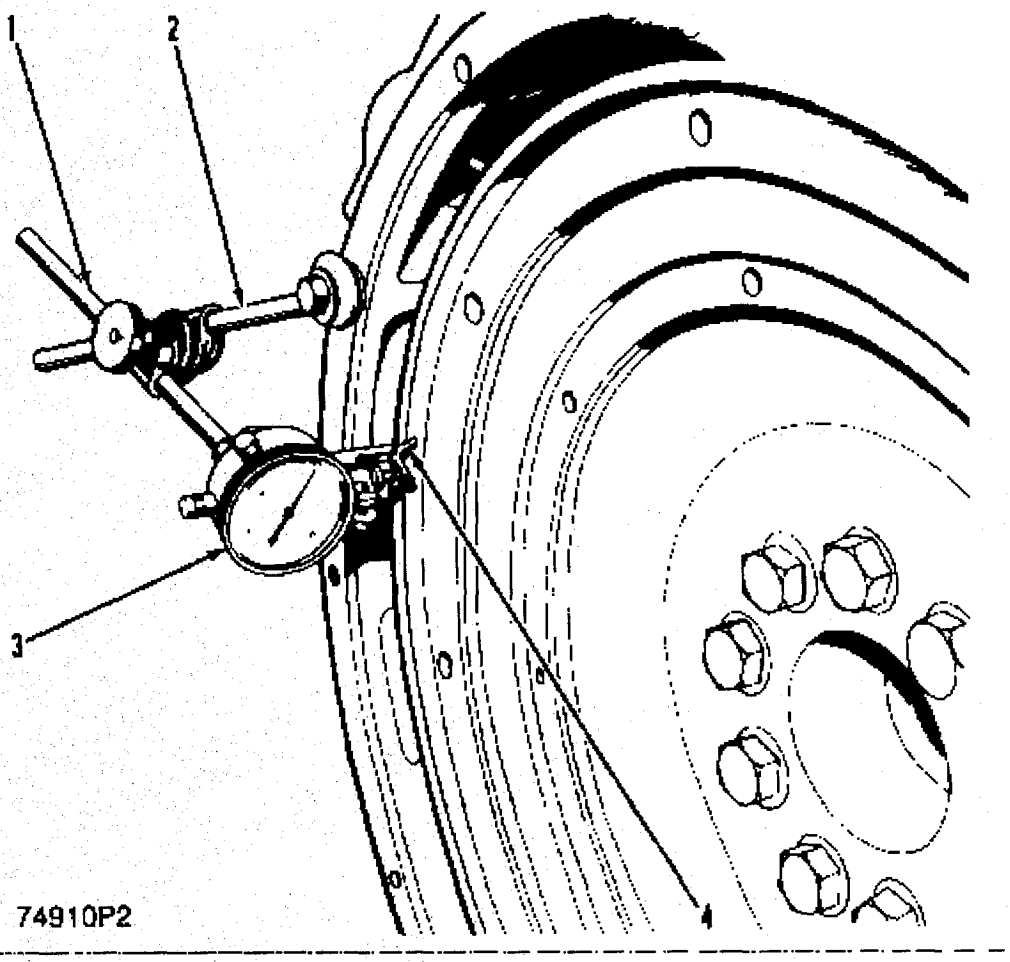
Checking Face Runout Of The Flywheel

2. Set the dial indicator to read 0.0 mm (.000 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.

Bore Runout (Radial Eccentricity) Of The Flywheel



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

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

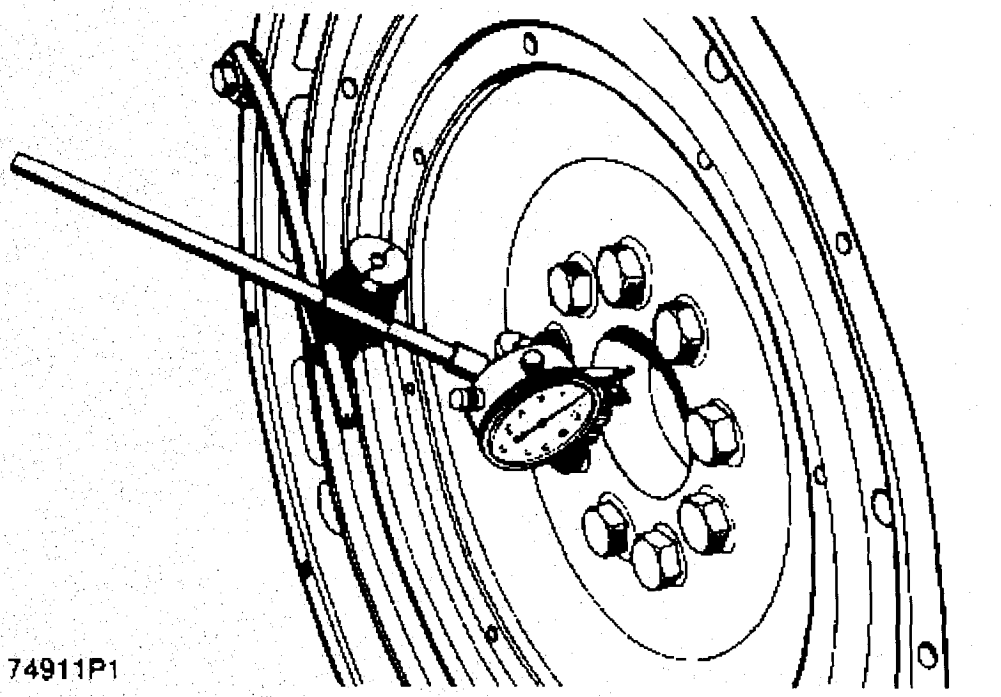
2. Set the dial indicator to read 0.0 mm (.000 in).

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:

Flywheel without BrakeSaver ... 0.15 mm (.006 in)

Flywheel with BrakeSaver ... 0.25 mm (.010 in)



Checking Flywheel Clutch Pilot Bearing Bore

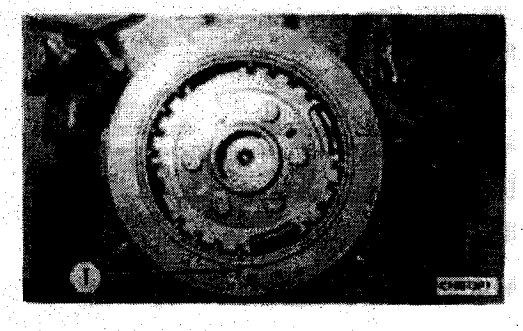
5. Runout (eccentricity) of the bore for the pilot bearing for the flywheel clutch, must not exceed:

Flywheel without BrakeSaver ... 0.13 mm (.005 in)

Flywheel with BrakeSaver ... 0.25 mm (.010 in)

Vibration Damper

Damage to or failure of the damper will increase vibrations and result in damage to the crankshaft and may cause more gear train noise at certain engine speeds.



Vibration Damper
(1) Alignment marks.

The vibration damper has alignment marks (1) on the hub and the ring. These marks give an indication of the condition of the vibration damper. If the marks are not in alignment, the rubber part

(between the ring and the hub) of the vibration damper has had a separation from the ring and/or hub. Install a new vibration damper.

A used vibration damper can have a visual wobble (movement to the front and then to the rear when in rotation) on the outer ring and still not need replacement, because some wobble of the outer ring is normal. To see if the amount of wobble is acceptable, or replacement is necessary, check the damper with the procedure that follows:

1. Install a dial indicator, contact point and other parts as necessary to hold the dial indicator stationary. The contact point must be perpendicular (at 90 degrees angle) to the face of the outer ring of the damper, and must make contact approximately at the center of the outer ring.

2. Push on the front end of the crankshaft so the end play (free movement on the centerline) is removed. Keep the crankshaft pushed back until the measurements are done.

3. Adjust the dial indicator to zero.

4. Turn the crankshaft 360 degrees and watch the dial indicator. A total indicator reading of 0.00 to 2.03 mm (.000 to .080 in) is acceptable.

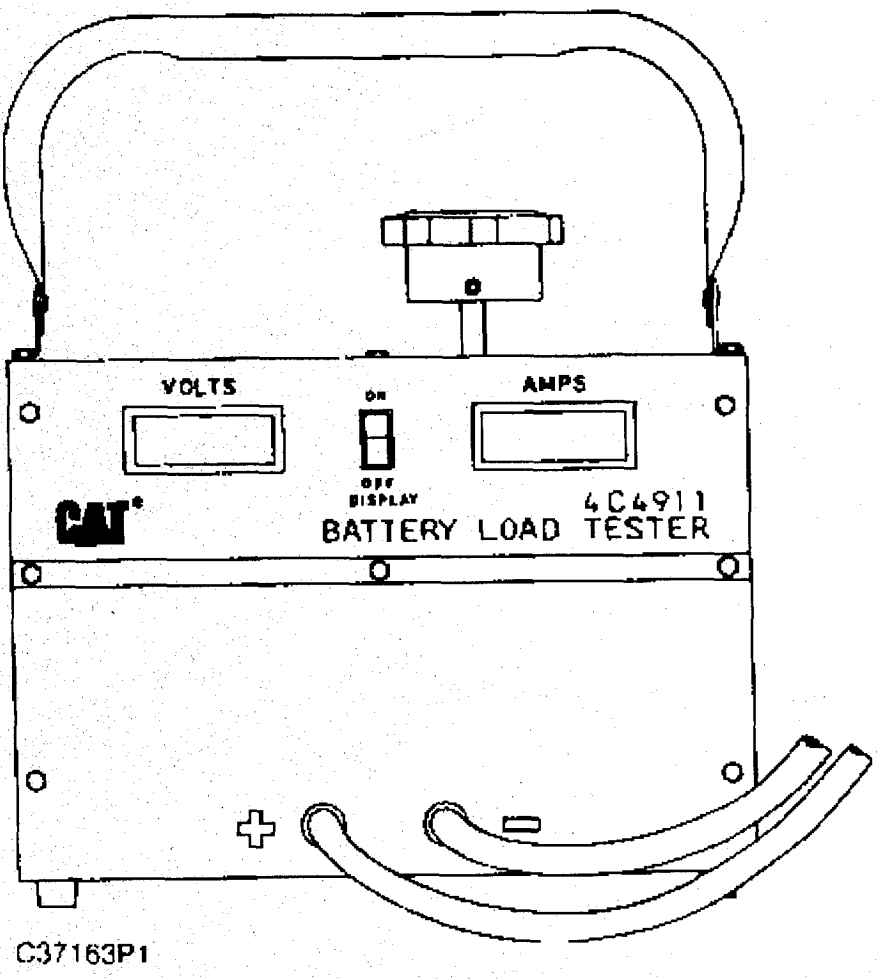
Electrical System

Test Tools For Electrical System

Tools Needed		
4C4911	Battery Load Tester	1
6V7070	Heavy-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, REG00636 has complete specifications and procedures for the components of the starting circuit and the charging circuit.

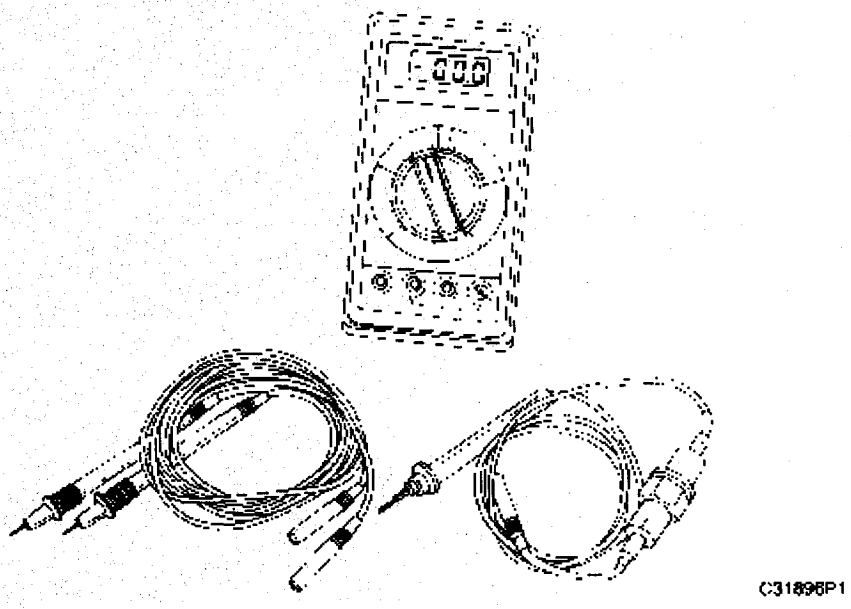


4C4911 Battery Load Tester

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, SEHS9249 for more complete information for use of the 4C4911 Battery Load Tester.



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.

NOTE: Make reference to Special Instruction SEHS7734 for more complete information for use of the 6V7070.

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.

Before any testing is done on the electrical system, the batteries should be checked for good connections and must be at least 75 percent (1.225 Sp Gr) fully charged.

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 will 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 will damage, not only the charging unit, but also the regulator and other electrical components.

Use the 4C4911 Battery Load Tester to load test a battery that does not hold a charge when in use. Refer to Operating Manual, SEHS9249 for more detailed instructions on use of the 4C4911 Battery Load Tester. See Special Instruction, SEHS7633 for the correct procedure and specifications to use when testing batteries.

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.

To check for correct output of the alternator, see the Specifications module.

For complete service information, refer to Service Manual Module, SENR3862, Delco Remy 27-SI Series Alternators. This module is part of REG00636 Service Manual.

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.

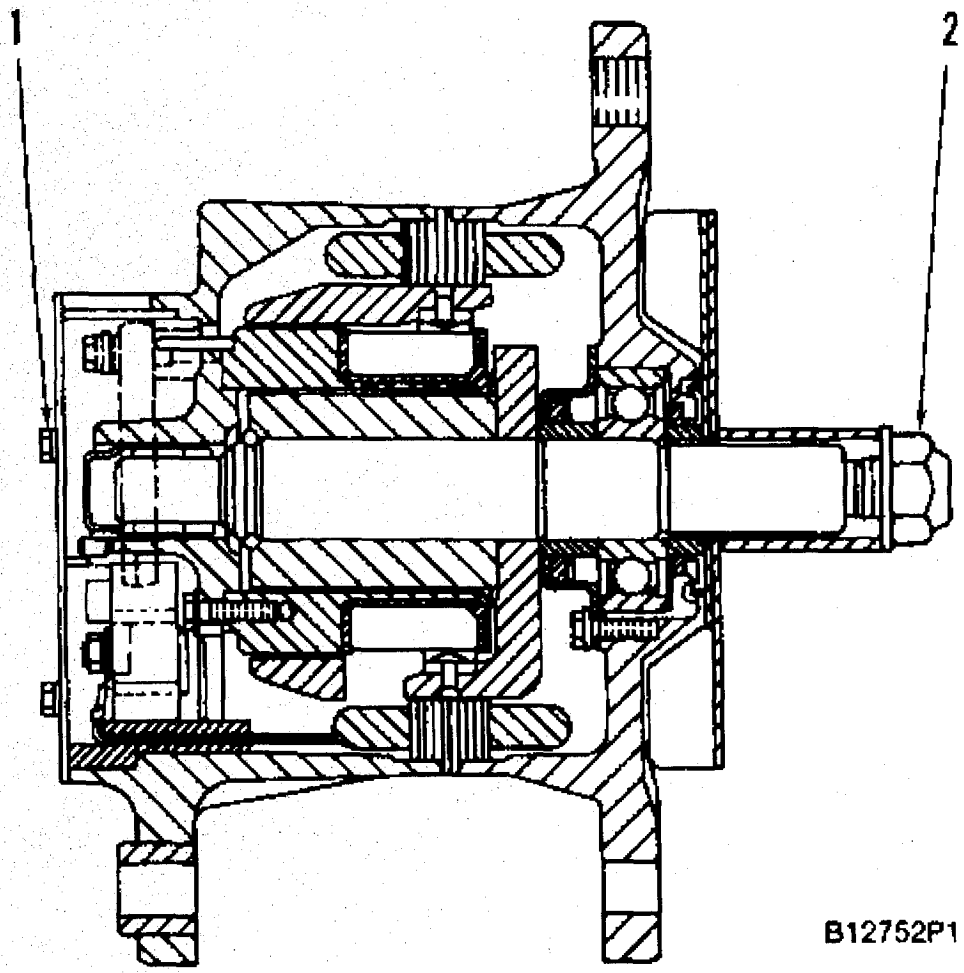
2. Cables between the battery, starter and engine ground must be the correct size. Wires and cables must be free of corrosion and have cable support clamps to prevent stress on battery connections (terminals).

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

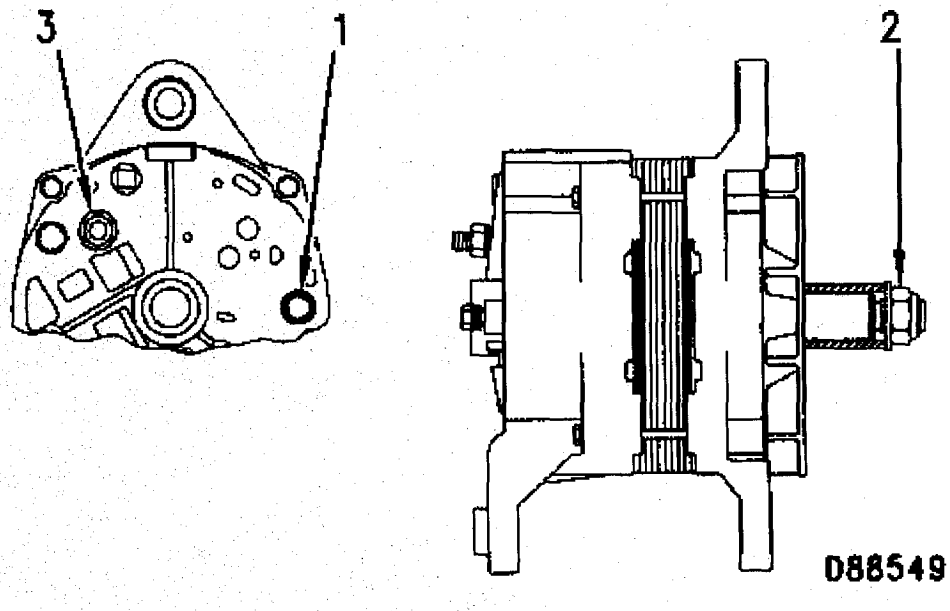
4. Inspect the drive components for the charging unit to be sure they are free of grease and oil and have the ability to operate the charging unit.

Alternator Regulator Adjustment (5N5692 or 9X6796)

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.



5N5692 Alternator
(1) Ground terminal. (2) Pulley nut.

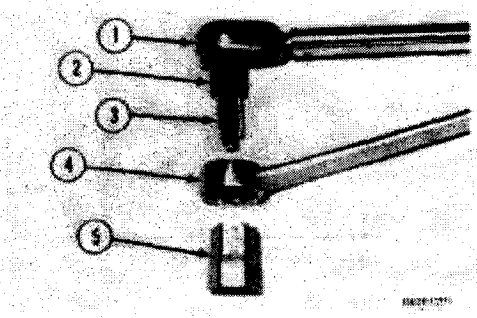


9X6796 Alternator
(1) Ground terminal. (2) Pulley nut. (3) Battery terminal.

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 (5N5692 or 9X6796)

Tighten nut that holds the pulley to a torque of 102 ± 7 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 starting motor is engaged with the ring gear on the engine flywheel.

If the solenoid for the starting 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.

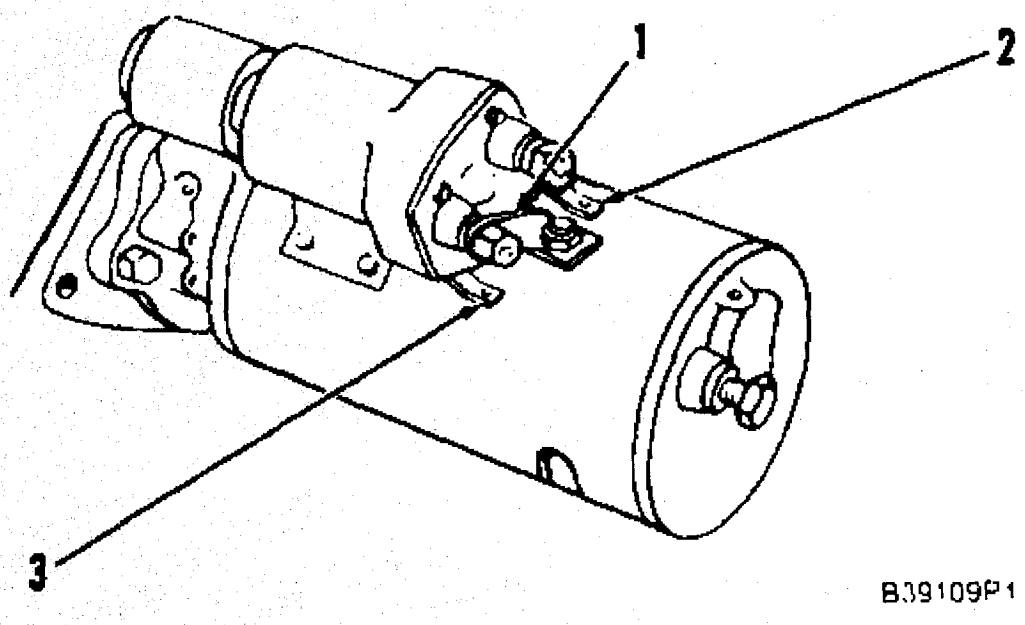
Make a test with one multimeter lead fastened to the connection (terminal) for the small wire at the solenoid and the other lead to the ground. Look at the multimeter and activate the starter solenoid. A voltage reading shows that the problem is in the solenoid. A zero reading is an indication that the 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 starting motor that operates too slow can have an overload because of too much friction in the engine being started. Slow operation of the starting motor can also be caused by a short circuit, loose connections and/or dirt in the motor.

Pinion Clearance Adjustment (7T0796)

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



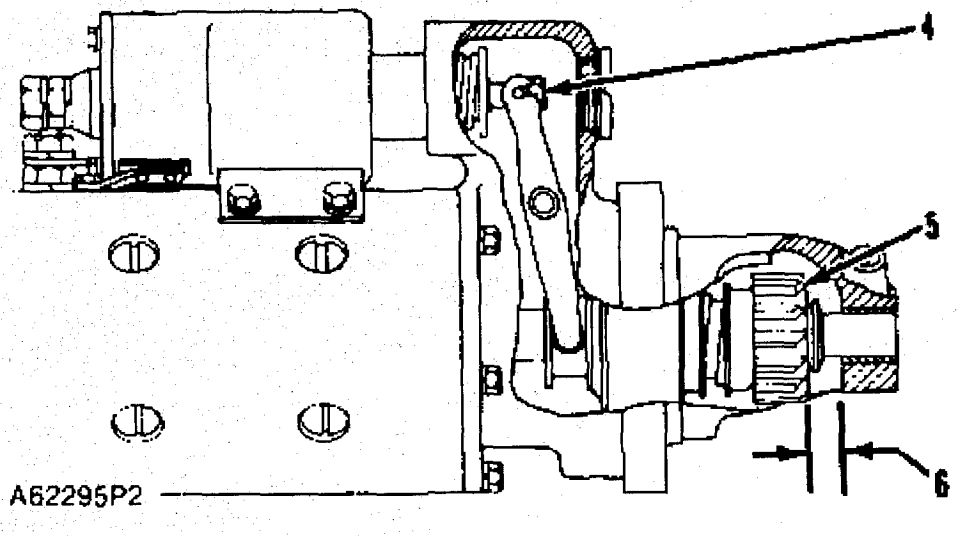
Connection For Checking Pinion Clearance
(1) Connector (from MOTOR terminal on solenoid to motor). (2) SW terminal (3) Ground terminal.

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

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

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.

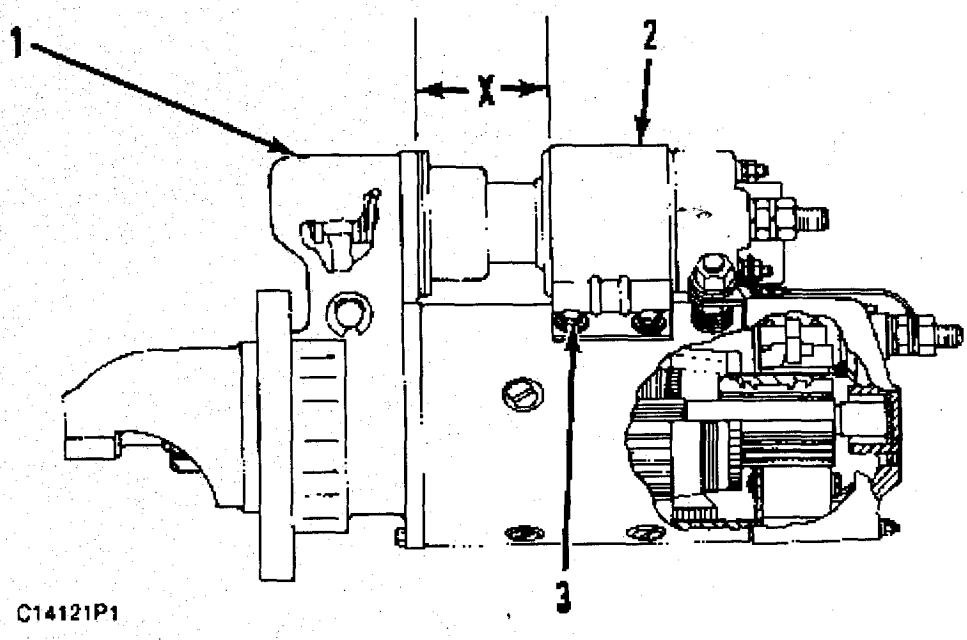
6. Pinion clearance (6) must be 8.3 to 9.9 mm (.33 to .39 in).

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

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

Pinion Clearance Adjustment (7T0795)

The solenoid position on the starting motor controls pinion clearance. If the solenoid position is correct, the pinion clearance is correct. Do the following procedure to adjust the solenoid position.



Solenoid Assembly
(1) Intermediate housing. (2) Solenoid mounting bracket. (3) Bolts. (X) 62.50 + 0.20 - 0.50 mm (2.46 + .008 - .020 in).

1. Check distance (X) between intermediate housing (1) and solenoid mounting bracket (2) with calipers.

2. If distance (X) is not correct, loosen bolts (3) and move the solenoid until distance (X) is correct. Solenoid mounting bracket (2) has elongated holes.

3. Tighten bolts (3) to 7 to 10 N·m (5 to 7 lb ft) after the adjustment is correct.

Wed Sep 21 13:54:32 PDT 2011