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Testing And Adjusting (Section 3)

Testing And Adjusting

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

a. Not enough air for good combustion.

b. An overload at high altitude.

c. Oil leakage into combustion chamber.

d. Not enough compression.

Fuel System Inspection

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

1. Check the fuel level in the fuel tank. Look at the cap for the fuel tank to make sure the vent is not filled with dirt.
2. Check the fuel lines for fuel leakage. Be sure the fuel supply line does not have a restriction or a bad bend.
3. Install a new fuel filter. Clean the fuel screen located in the inlet valve of the fuel transfer pump.
4. Remove any air that may be in the fuel system. Open the drain valve on the fuel injection pump housing. Operate the fuel priming pump until fuel without air comes from the drain lines. Close the drain valve.

To remove air from the fuel injection lines, loosen the fuel line nuts 1/2 turn. Move the governor lever to the low idle position. Crank the engine with the starter motor until fuel without air comes from the fuel line connections. Tighten the fuel line nuts.

Check 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 the 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 valves are:

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

c 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 Instruction, Form No. SEHS7292.

Fuel Injection Lines

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.

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

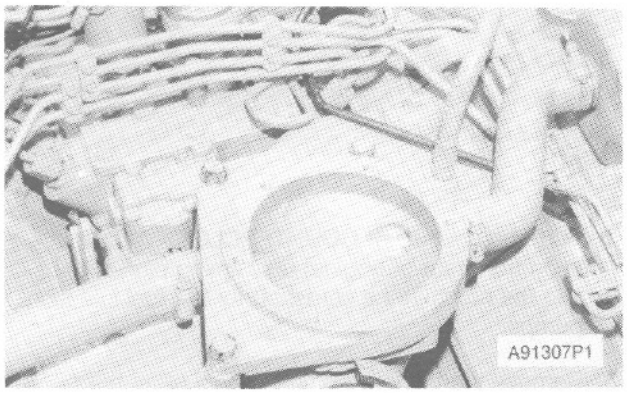
The nuts that hold a fuel injection line to an injection nozzle and injection pump must be tightened to the correct torque. If the nut is loose, fuel will leak from the connection. If the nut is tightened too tight, the inside diameter of the line will become smaller and cause a restriction to the flow of fuel in the line. Use a torque wrench and a 5P144 Fuel Line Socket to tighten the fuel injection line nuts to 42 ± 7 N•m (31 ± 5 lb ft).

Fuel Injection Pumps

When injection pumps, sleeves and lifters are removed from the injection pump housing, keep the parts of each pump together so they can be installed back in their original location.

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

When an injection pump is installed correctly, the plunger is through the sleeve and the adjustment lever is engaged with the groove on the sleeve. The bushing that holds the injection pump in the pump housing must be kept tight. Tighten the bushing to 80 ± 7 N•m (60 ± 5 lb ft). Damage to the housing will result if the bushing is too tight. If the bushing is not tight enough, the pump will leak.



Air Inlet Pipe

NOTICE

If the sleeves on one or more of the fuel injection pumps have been installed wrong, damage to the engine is possible if cautions are not taken at first starting. When the fuel injection pumps have been removed and installed with the fuel injection pump housing on engine, take the following cautions when first starting the engine.

a. Remove the air cleaner leaving the air inlet pipe open as shown.
b. Set the governor control at low idle.

⚠ WARNING

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

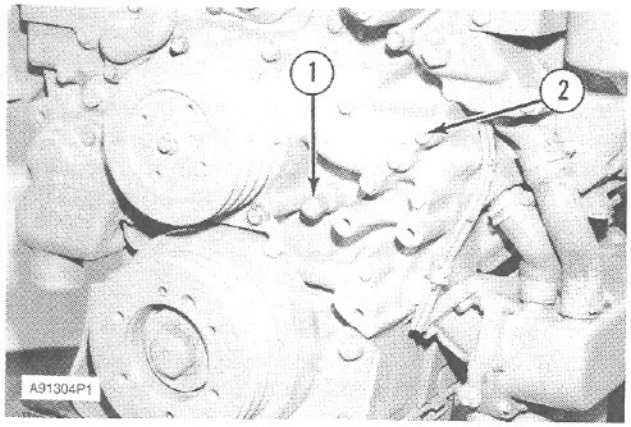
c. Start the engine, and if engine starts to overspeed (run out of control), put a steel plate over the air inlet as shown to stop the engine.

Stopping The Engine

Finding Top Center Compression Position For No. 1 Piston

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

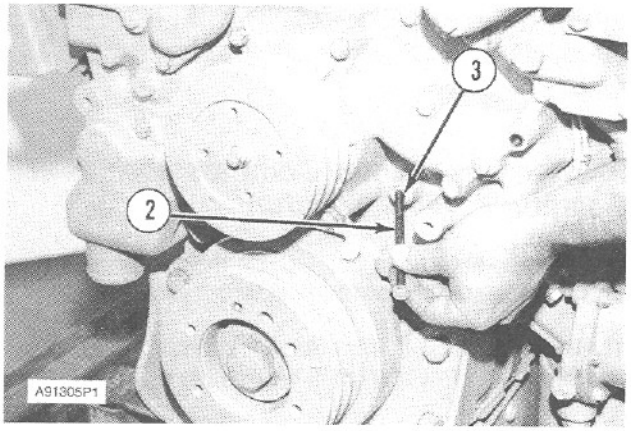
1. Remove fitting (1) from the timing hole (3) in the front cover. Put bolt (2) in timing hole (3).



Fitting And Bolt Location
(1) Fitting. (2) Bolt.

2. Turn the crankshaft COUNTERCLOCKWISE (as seen from rear of engine) until bolt (2) will go into the hole in the drive gear for the camshaft.

3. Remove the valve cover on the right side of the engine (as seen from rear of engine). The two valves at the right front of the engine are the intake and exhaust valves for No. 1 cylinder.



Installing Bolt
(2) Bolt. (3) Timing hole.

4. The intake and exhaust valves for No. 1 cylinder must now be closed and the timing pointer will be in alignment with the TDC-1 on the damper assembly. The No. 1 piston is now at top center on the compression stroke.

Fuel System Adjustments

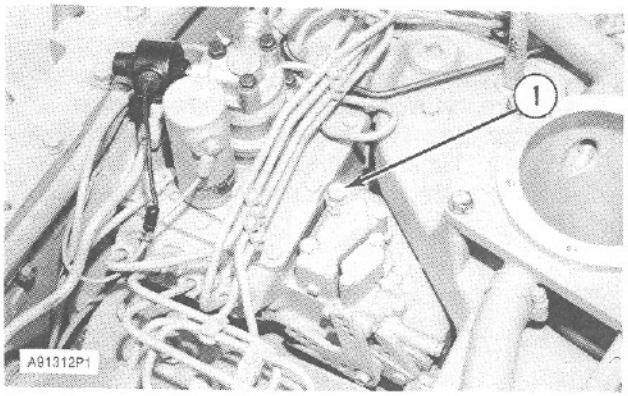
Checking Fuel Injection Pump Timing; On Engine

The timing of the fuel injection pump can be checked and changed if necessary, to make compensation for movement in the taper sleeve drive or worn timing gears. The timing can be checked and if necessary, changed using the following method.

Checking Timing by Timing Pin Method

Tools Needed		
6V4069	Puller	1
3P1544	Timing Pin	1

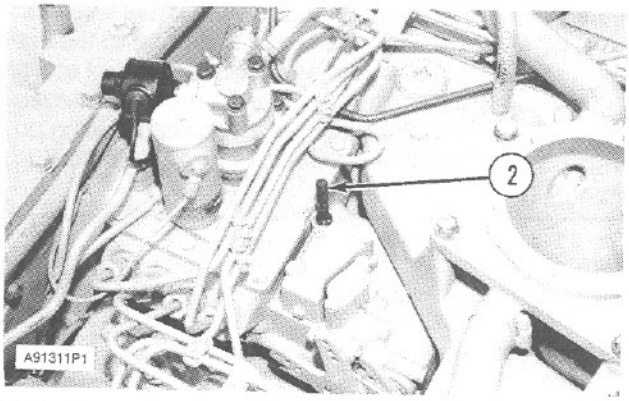
1. Remove bolt (1) from the timing pin hole.



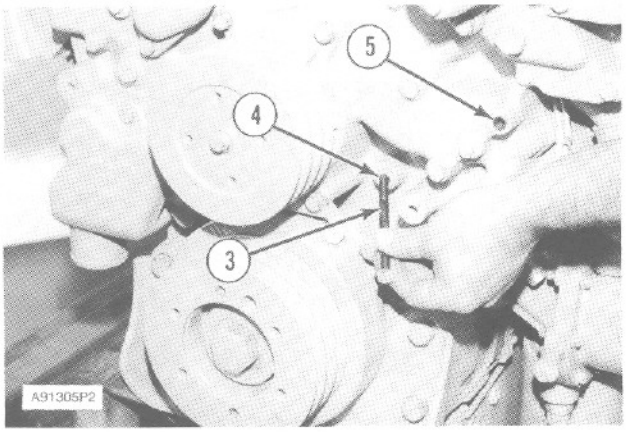
Timing Hole Bolt
(1) Bolt.

2. Turn the crankshaft COUNTERCLOCKWISE (as seen from rear of engine) until timing pin (2) goes into the notch in the camshaft for the fuel injection pumps.

3. Remove the fitting from timing hole (4) in the front cover. Put bolt (3) through the front cover and into the hole with threads in the timing gear. The bolt from hole (5) can be used.



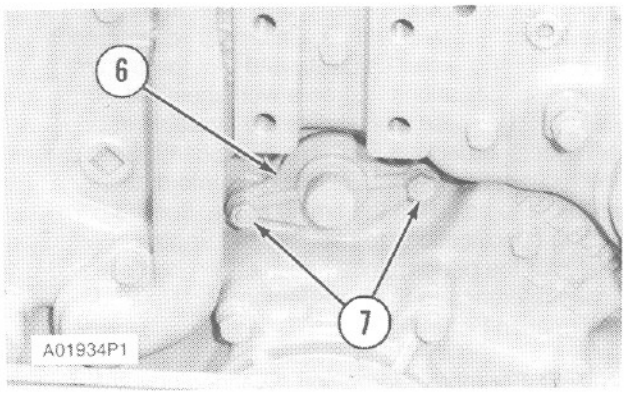
Timing Pin Installed
(2) 3P1544 Timing Pin.



Installing Bolt
(3) 1D4539 Bolt, 5/16 in-18 NC, 63.5 mm (2.5 in) long. (4) Timing hole. (5) Hole.

4. If the timing pin is in the notch in the camshaft for the fuel injection pumps, and bolt (3) goes into the hole in the timing gear through timing hole (4), the timing of the fuel injection pump is correct.

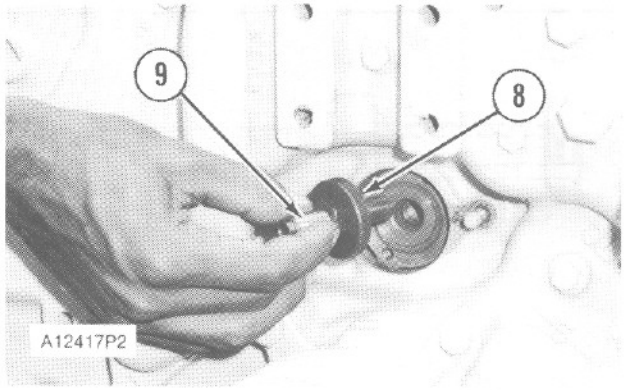
NOTE: If bolt (3) does not go in the hole in the timing gear with timing pin (2) in the notch in the camshaft, use the procedure that follows.



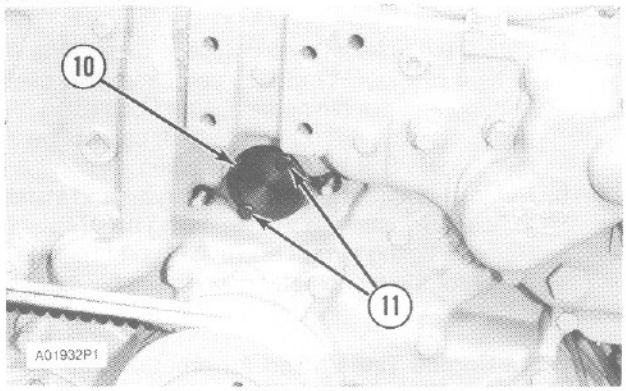
Location Of Cover
(6) Cover for the tachometer drive assembly. (7) Nuts.

a. Remove nuts (7) and the cover for the tachometer drive assembly (6).
b. Remove the tachometer drive shaft (9) and washer (8) from the camshaft for the fuel injection pumps.

NOTE: Tachometer drive shaft (9) and washer (8) are removed as an assembly.

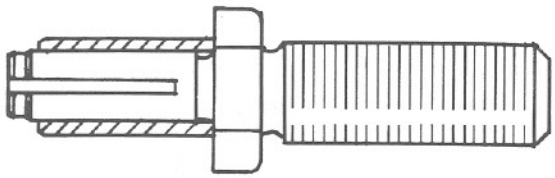


Location Of Bolt
(8) Washer. (9) Tachometer drive shaft.



Loosening Drive Gear
(10) 6V4069 Puller. (11) Bolts.

c. Put 6V4069 Puller (10) on the camshaft for the fuel injection pumps. Tighten bolts (11) until the drive gear on the camshaft for the fuel injection pumps comes loose.
d. Remove the 6V4069 Puller.
e. Turn the crankshaft COUNTERCLOCKWISE (as seen from rear of engine) until bolt (3) goes into the hole in the timing gear. With timing pin (2) in the notch in the camshaft for the fuel injection pumps, and bolt (3) in the hole in the timing gear, the timing for the engine is correct.
f. Install washer (8) and tachometer drive shaft (9). Tighten tachometer drive shaft to 149 ± 14 N•m (110 ± 10 lb ft). Remove timing pin (2).



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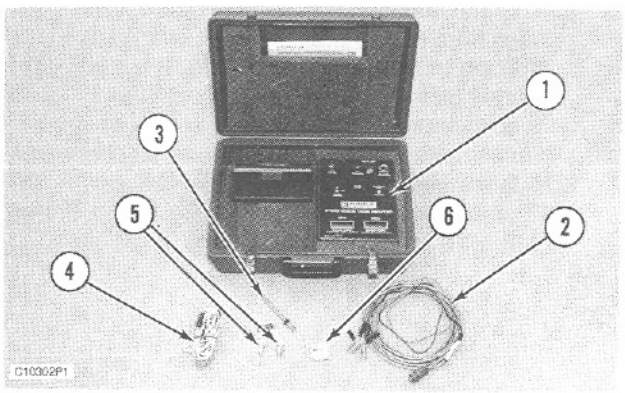
Tachometer Drive Shaft

g. Turn the crankshaft two complete revolutions COUNTERCLOCKWISE (as seen from rear of engine) and put timing pin (2) and bolt (3) in again. If timing pin (2) and bolt (3) can not be installed do Steps a through f again.
h. Remove bolt (3) from the timing gear and install in hole (5). Install the plug in timing hole (4). Remove timing pin (2) and install bolt (1). Install cover for the tachometer drive assembly (6).

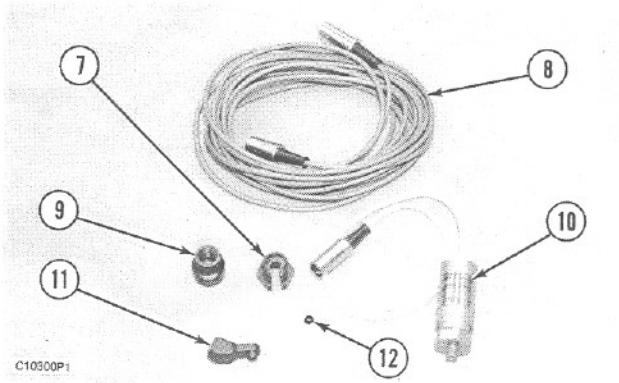
Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group And 8T5301 Diesel Timing Adapter Group

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



8T5300 Timing Indicator Group
(1) 8T5250 Engine Timing Indicator. (2) 5P7366 Cable Assembly. (3) 6V2197 Magnetic Transducer. (4) 5P7362 Cable. (5) 6V2199 & 6V3093 Transducer Adapters. (6) 8K4644 Fuse.

The 8T5300 Timing Indicator Group must be used with an 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 that has a mechanical advance, Caterpillar recommends that the serviceman calculate and plot the dynamic timing specifications first on a worksheet like Form No. SEHS8140. These worksheets are available in pads of 50 sheets, order one Form No. SEHS8140. See Special Instruction, Form No. SEHS8580 for information required to calculate the timing curve. For the correct timing specifications to use, see the Engine Information Plate for the performance specification number and make reference to the Fuel Setting And Related Information Fiche.

NOTE: For more information on acceptable tolerances for dynamic fuel injection timing, see Service Magazines dated 4-1-85 and 10-28-85.

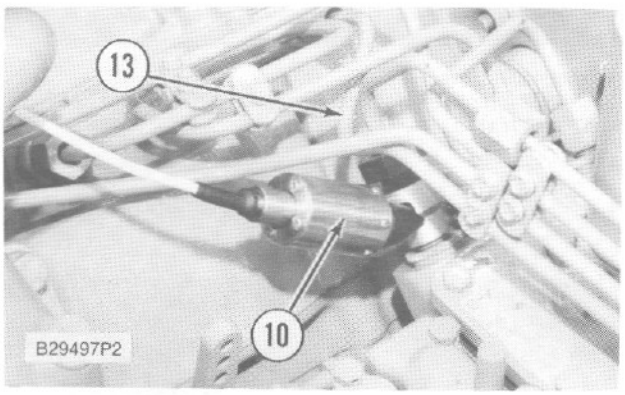
After the timing values are calculated and plotted, the dynamic timing should be checked with the 8T5300 Timing Indicator Group and the 8T5301 Diesel Timing Adapter Group. To do this, the serviceman must operate the engine from 1000 rpm (base rpm) to high idle and from high idle to 1000 rpm (base rpm). Unstable readings are often obtained below 1000 rpm. He must record the dynamic timing at each 100 rpm and at the specified speeds during both acceleration and deceleration. Then he should plot the results on the worksheet.

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

1. Make reference to Special Instruction, Form No. SEHS8580 for complete service information and use of 8T5300 Timing Indicator Group.

2. Loosen all fuel line clamps that hold No. 1 fuel injection line and disconnect fuel injection line (13) for No. 1 cylinder at the fuel injection pump. Slide the nut up and out of the way. Put 5P7436 Adapter (9) in its place and turn 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.

3. Put the 5P7435 Adapter (11) on 6V7910 Transducer (10) and put the end of the 5P7435 Adapter (11) in the "window" of the 5P7436 Adapter (9).

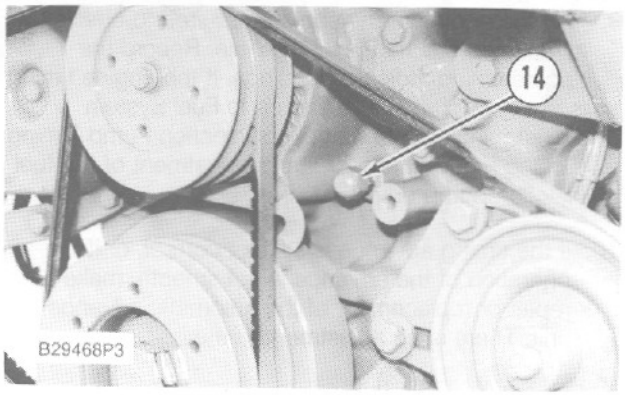


Transducer In Position
(10) Injection transducer. (13) Fuel injection line for No. 1 cylinder.

4. Put fuel injection line (13) on top of 5P7435 Adapter (11). Install 5P7437 Adapter (7) and tighten to 40 N•m (30 lb ft).

5. Remove fitting (14) from the front housing. Install transducer adapter (5) into hole fitting (14) was removed from. Tighten only a small amount.

6. Push the TDC magnetic transducer (3) into the transducer adapter (5) until it makes contact with the camshaft gear. Pull it back out 1.6 mm (.06 in) and lightly tighten the knurled locknut.

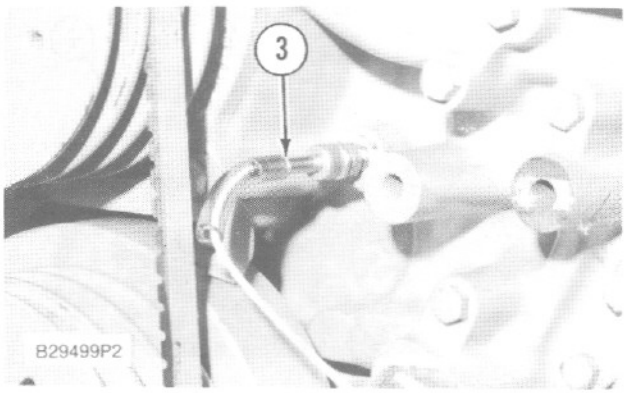


Location Of Fitting
(14) Fitting.

7. Connect the cables from the transducers to the Engine Timing Indicator. Make a calibration check of the indicator. For caon check of the indicator. For calibration procedure, make reference to Special Instruction, Form No. SEHS8580.

NOTICE

Be sure all test equipment cables are routed so they will not come into contact with the V-belts or other rotating components.



Transducer In Position
(3) TDC magnetic transducer.

⚠ WARNING

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

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

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

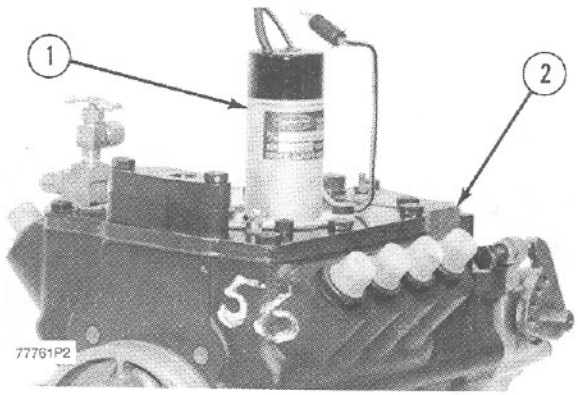
10. If the timing advance is still not correct, or if the operation of the advance is not smooth, make a repair or replacement of the automatic advance unit. There is no adjustment to the unit.

Fuel Setting

Tools Needed		
5P4203	Field Service Tool Group	1

The procedure that follows for fuel setting can be done with the housing for the fuel injection pumps either on or off the engine.

NOTE: If the fuel injection pump group is equipped with a fuel ratio control, the control must be removed before the fuel setting is checked or adjusted.



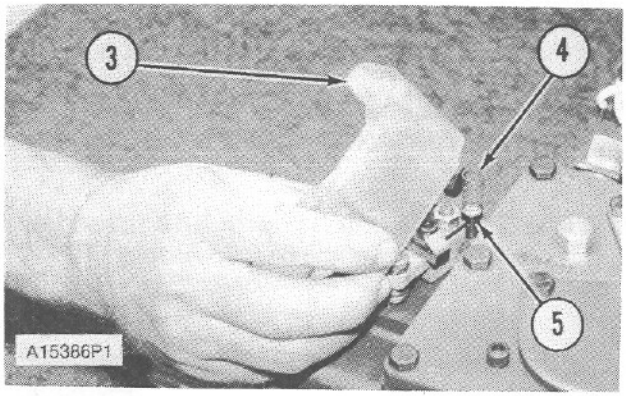
Removal Of Covers
(1) Shutoff solenoid. (2) Top cover.

NOTICE
Before any service work is done on this fuel system, the outside of the housing for the fuel injection pumps and all parts connected to it must be especially clean.

1. Remove shutoff solenoid (1) and cover (2).

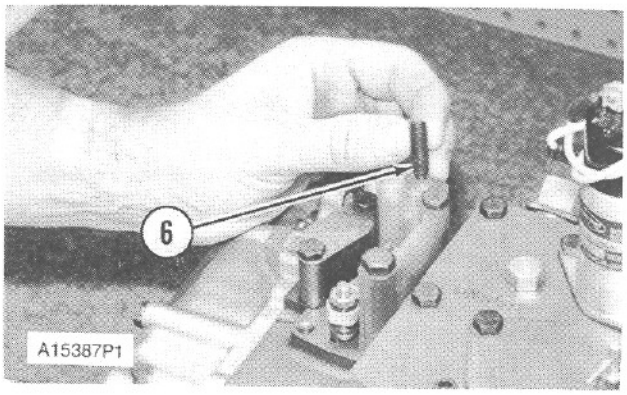
2. Put the 5P0298 Zero Set Pin (5), with 17.8507 on it, in the pump housing.

3. Put adapter (3) and spring (4) over zero set pin (5). Use a 1D4533 Bolt and a 1D4538 Bolt to fasten adapter (3) to the housing for the fuel injection pumps.



Installation Of Cover
(3) 5P6602 Adapter. (4) 3J6956 Spring. (5) 5P0298 Zero Set Pin, with 17.8507 on it.

4. Put screw (6) in the hole over pin (5) and spring (4).

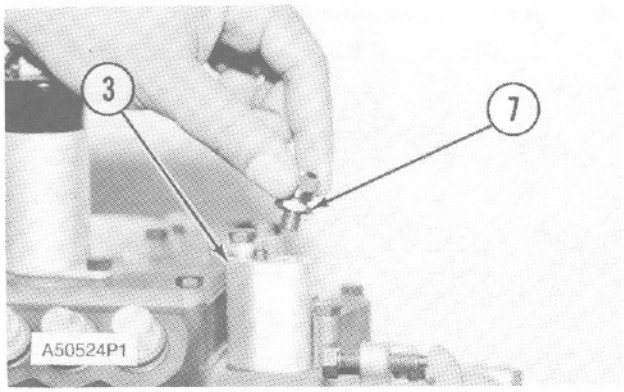


Installation Of Screw
(6) 8S7271 Screw.

5. Turn screw (6) clockwise until pin (5) is held against the housing for the fuel injection pump. DO NOT tighten screw (6) too tight.

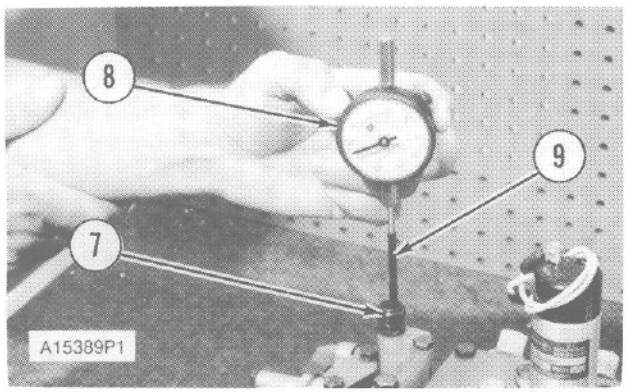
6. Put clamp (7) in adapter (3).

7. Move the governor control lever to FULL LOAD position.

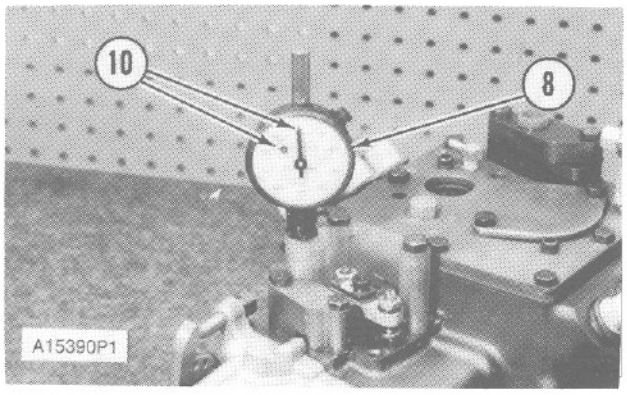


Installation Of Clamp
(3) Adapter. (7) 3P1565 Collet clamp.

8. Put 5P6531 Point (9) on dial indicator (8). Put the indicator assembly in clamp (7).



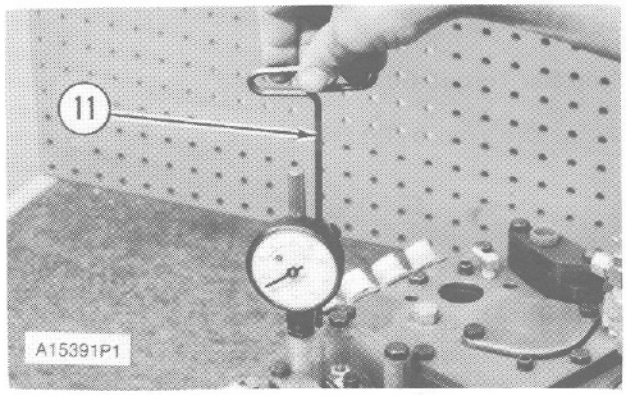
Installation Of Dial Indicator
(7) 3P1565 Collet Clamp. (8) 3P1567 Dial Indicator. (9) 5P6531 Contact Point, 57.2 mm (2.25 in) long.



Indicator Set On Zero
(8) 3P1567 Dial Indicator. (10) Pointers.

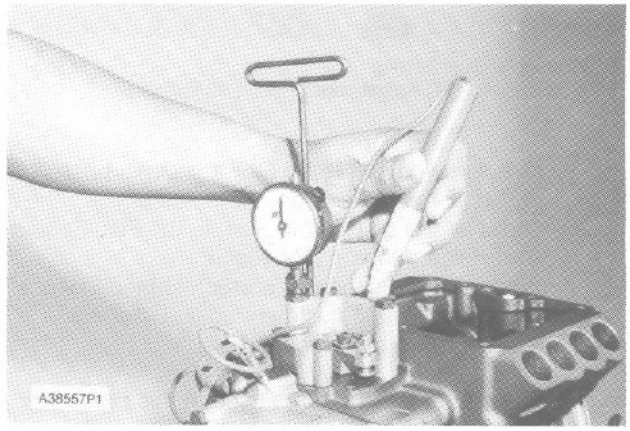
9. Adjust dial indicator (8) so both pointers (10) are on "0" (zero).

10. Use wrench (11) to turn the 8S7271 Screw (6) counterclockwise. Turn screw (6) six or more turns.



Loosening Screw (6)
(11) 5P4205 Wrench.

11. Put the clip end of the 8T0500 Circuit Tester to a good ground. Put the other end of the 8T0500 Circuit Tester on the load stop contact.



8T0500 Circuit Tester

12. Move the governor control lever to the LOW IDLE position.

13. Move the governor control lever slowly toward the HIGH IDLE position until the continuity light just comes on. Make a note of the reading on dial indicator (8). Do this step several times to make sure the reading is correct.

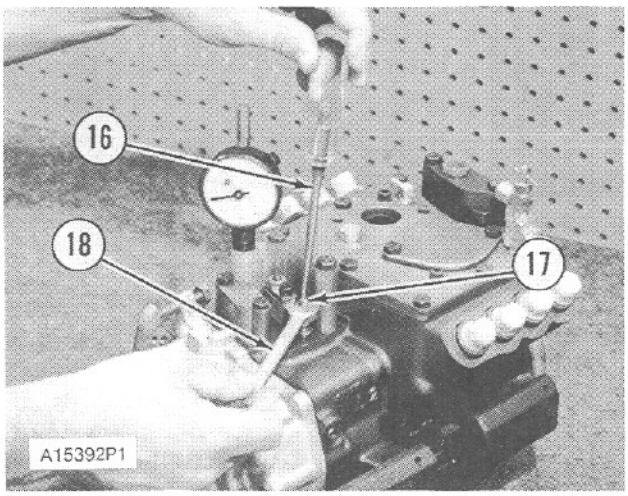
14. Make a comparison of this reading and the fuel setting in the Fuel Setting And Related Information Fiche.

15. If the reading on dial indicator (8) is not correct, do the fo the following.

Load Stop Adjustment

Stop Bar Torque Control Group

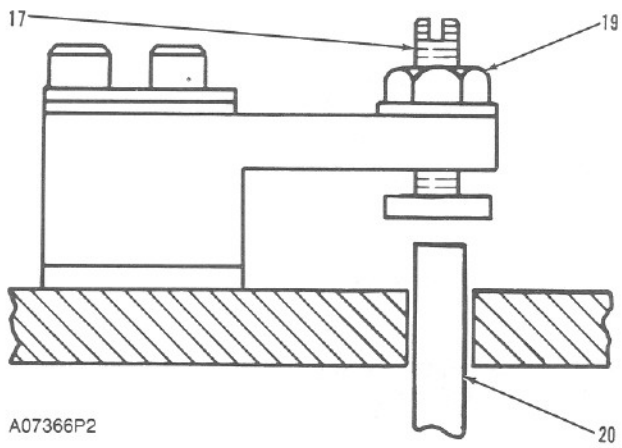
a. Use wrench (18) and locknut (19).



Adjustment Of Fuel Setting
(16) Screwdriver. (17) Adjustment screw. (18) Wrench.

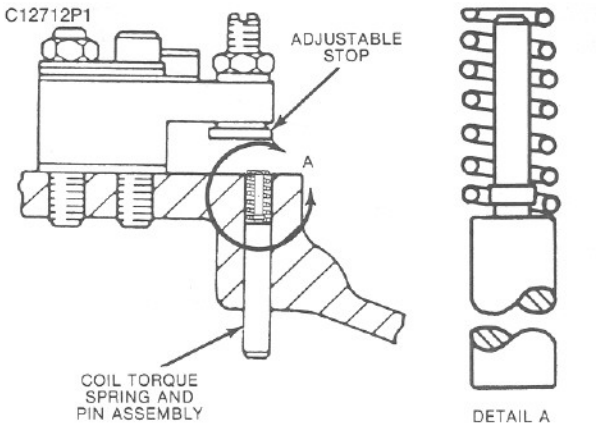
b. Use screwdriver (16) to turn adjustment screw (17) until the reading on dial indicator (8) is the same as the dimension given in the Fuel Setting And Related Information Fiche.
c. When the adjustment is correct, tighten locknut (19). Check the adjustment again by doing Steps 11 through 15 again.

NOTE: The same tools that are used in this procedure are also used for the fuel ratio control adjustment.



Adjustment Screw For Fuel Setting
(17) Adjustment screw. (19) Locknut. (20) Load stop pin.

Coil Type Torque Control Group



A coil type spring control group has been added to 3208 truck engines rated at 160 kW (215 hp) @ 2200 rpm. The new 4W9007 Pin Assembly (detail A) is a direct replacement for the load stop pin 4N0443 effective with Engine Serial No. 2Z34221. This new pin assembly can be adapted to 3208 truck engines 2Z13750 through 2Z34220, which have the above engine rating specifications.

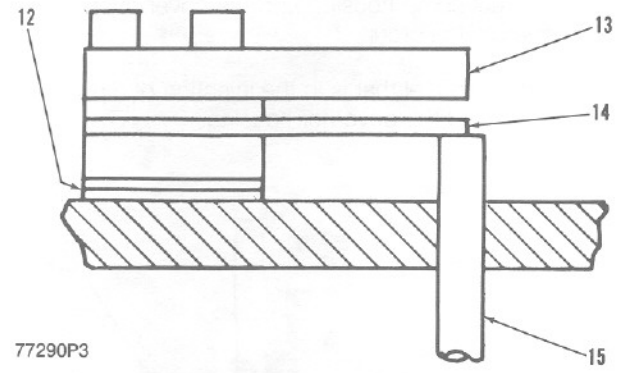
The coil type torque control group improves the torque rise as the engine lugs below full load rpm. The pin and spring assembly are matched and must be kept together.

Leaf Type Torque Spring

a. Write down the dimension that is on dial indicator (8).

b. Write down the dimension given in the Fuel Setting And Related Information Fiche.

c. Remove the test tools [adapter (3), spring (4), and dial indicator (8)] from the housing for fuel injection pumps.



Leaf Type Torque Spring
(12) Location of shims. (13) Stop bar. (14) Leaf type torque spring. (15) Load stop pin.

d. Install or remove shims at location (12) to get the correct dimension as given in the Fuel Setting And Related Information Fiche. The difference between the dimensions in (a) and (b) is the thickness and amount of shims to remove or install to get the correct setting.

e. Install the correct amount of shims (12) torque spring (14), and stop bar (13) on the housing for the fuel injection pumps.

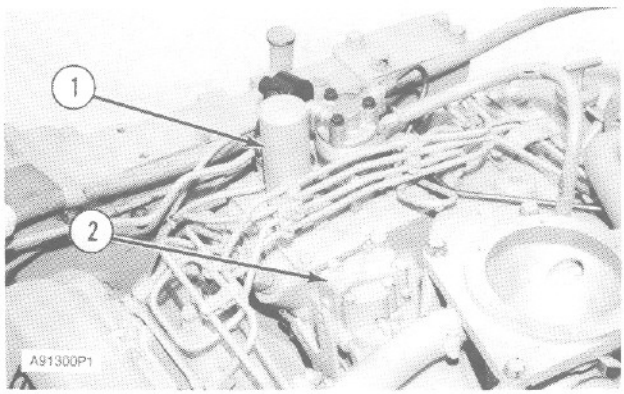
f. Install the test tools and do the test procedure again. Do this until the dimension on the dial indicator is the same as the dimension given in the Fuel Setting And Related Information Fiche. After the fuel setting is correct, remove the test tools. Install cover (2) and shutoff solenoid (1).

Fuel Ratio Control Adjustment

NOTE: The same tools are needed for the fuel ratio control adjustment that were used for the fuel setting. Make reference to Fuel Setting for the tools needed and instructions to install the tools.

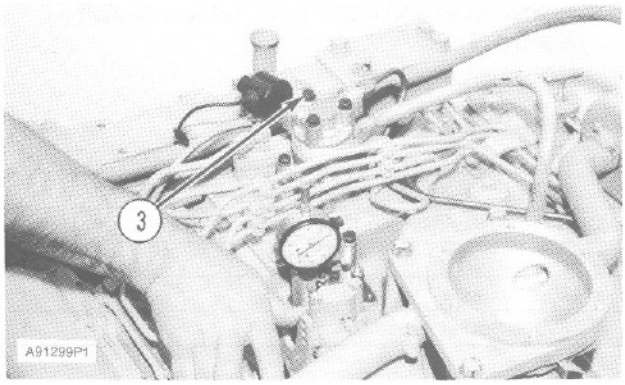
NOTE: The fuel setting must be correct before an adjustment is made to the fuel ratio control. Make reference to Fuel Setting.

1. Remove shutoff solenoid (1) and cover (2). Install tools and "zero" dial indicator as shown in Fuel Setting Steps 2 through10.



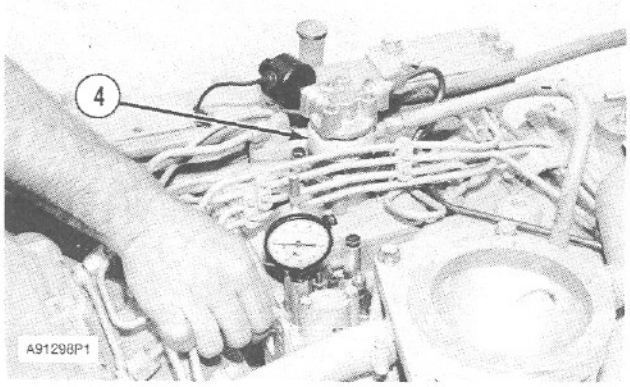
Removal Of Covers
(1) Shutoff solenoid. (2) Cover.

2. To check the fuel ratio control setting, move the governor lever slowly to the high idle position. Make a record of the reading on the dial indicator. Compare the reading with the specification given in the Fuel Setting And Related Information Fiche.



Checking Fuel Ratio Control Setting
(3) Bolts.

3. If an adjustment is needed, remove three bolts (3) from the fuel ratio control. Hold the governor lever in the high idle position and turn flange (4) until the fuel ratio control setting is correct.



Adjustment Of Fuel Ratio Control Setting
(4) Flange.

4. Move governor lever to low idle and again move the lever slowly to high idle to check the fuel ratio control setting.

5. Install bolts (3). Flange (4) can be turned a small amount to give alignment for bolts (3).

6. Remove tools and install cover (2) and shutoff solenoid (1).

Crossover Levers

Tools Needed		
3P1546	Calibration Pin	1
5P4206	Wrench	1
5P4209	Gauge	1
5P7253	Socket Assembly	1

Checking Crossover Levers

NOTE: The crossover levers normally do not need checking unless one or more of the following conditions exist (after the timing is checked and the other corrections shown in Troubleshooting have been made):

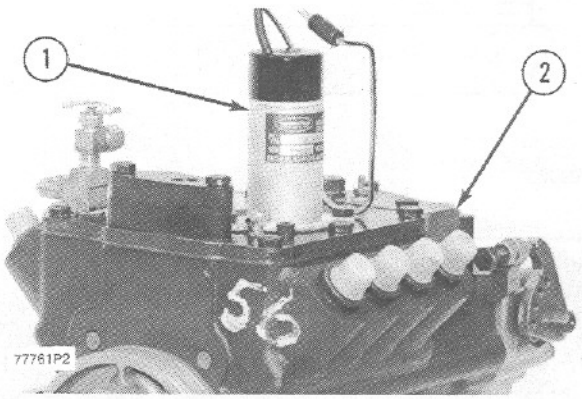
A. The engine produces too much black smoke.
B. The engine runs rough because fuel delivery is not even.
C. Some cylinders continue to fire at fuel shutoff position.
D. The complete injection group is being reconditioned.

NOTICE

Before any service work is done on this fuel system, the outside of the injection pump housing and all parts connected to it must be clean.

1. Remove the fuel shutoff solenoid (1), top cover (2) of the fuel pump housing and the cover over the torque control group.

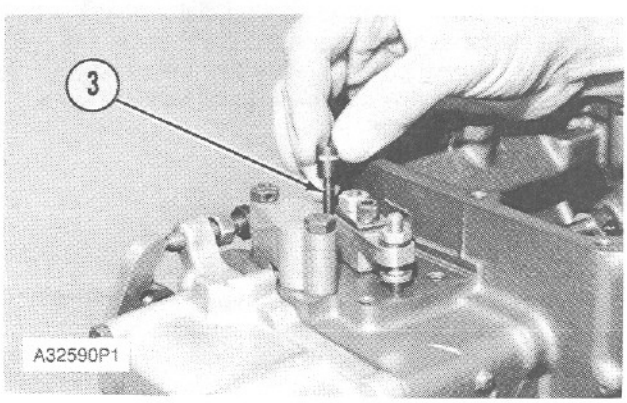
2. Remove the fuel that is in the injection pump housing and the governor housing.



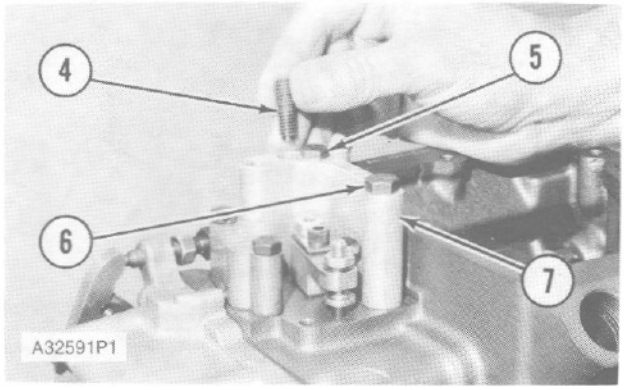
Removal Of Covers
(1) Shutoff solenoid. (2) Top cover.

3. Put the 3P1546 Calibration Pin (3) in calibration hole as shown.

4. Install the 5P6602 Adapter (7) as shown. Fasten it in position with a 1D4533 Bolt (5) and a 1D4538 Bolt (6).

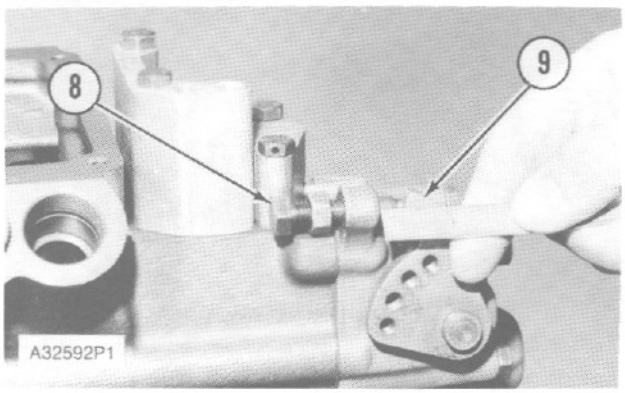


Installing Calibration Pin
(3) 3P1546 Calibration Pin with 15.9410 on it.



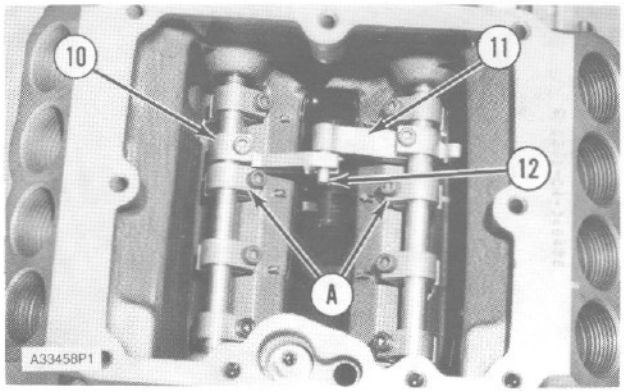
Installing 5P6602 Adapter And 8S7271 Screw
(4) Screw. (5) 1D4533 Bolt. (6) 1D4538 Bolt. (7) 5P6602 Adapter.

5. Put the 8S7271 Screw (4) (setscrew) in the hole over the calibration pin (3). Tighten the setscrew (4) to 2.3 to 2.8 N•m (20 to 25 lb in) with the 2P8264 Socket.



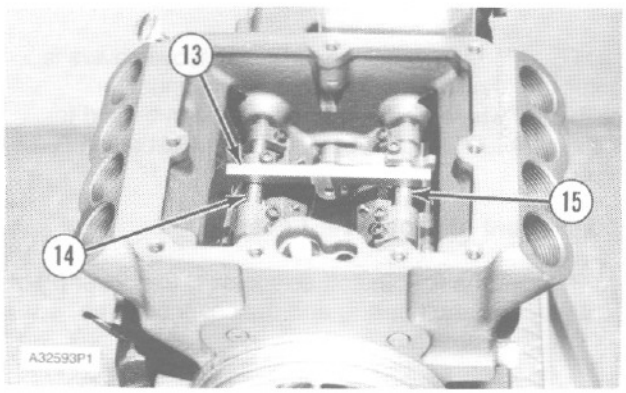
Adjustment Of Low Idle Screw
(8) Low idle screw. (9) Lever.

6. Adjust low idle screw (8) to position lever (9) to 8.9 ± 1.0 mm (.35 ± .04 in) from governor housing boss.



Crossover Levers
(10) Crossover lever. (11) Crossover lever. (12) Dowel pin.
(A) Sleeve levers.

7. Loosen the bolts that hold sleeve levers (A) and slide levers (A) out of the way.

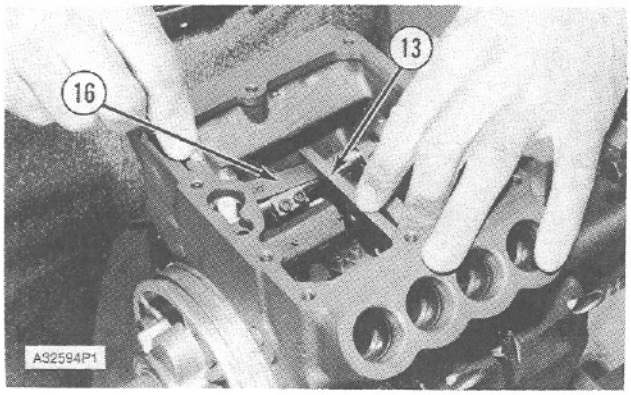


Installing 5P4209 Gauge
(13) 5P4209 Gauge. (14) Shaft. (15) Shaft.

8. Put gauge (13) on shafts (14) and (15). Slide gauge (13) toward crossover levers (10) and (11) until dowel pin (12) goes into hole in gauge (13).

9. If dowel pin (12) must be lifted to go into the hole in gauge (13), the levers must be adjusted. See Adjustment Of Crossover Levers.

10. If gauge (13) must be lifted more than 0.20 mm (.008 in) to let dowel pin (12) go into the hole in gauge (13), see Adjustment Of Crossover Levers.



Checking Clearance Of Crossover Lever
(13) 5P4209 Gauge. (16) Feeler gauge.

11. To check the maximum clearance of 0.20 mm (.008 in) that is acceptable under one side of gauge (13), hold the center and one side of gauge (13) against sleeve lever shaft (15). Use a feeler gauge to check clearance.

NOTE: After the checking of the crossover levers is complete, the two fuel injection pumps must be calibrated where sleeve levers have been moved to install 5P4209 Gauge. See Fuel Pump Calibration.

Adjustment of Crossover Levers

1. Remove the fuel shutoff solenoid (1) top cover (2) of the fuel pump housing and the cover over the torque control group.

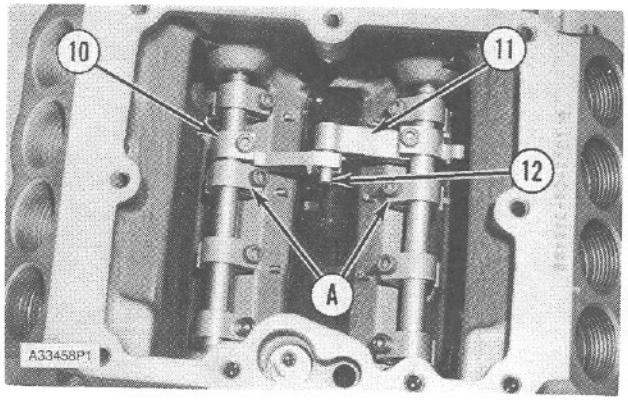
2. Remove the fuel that is in the injection pump housing and the governor housing.

3. Put the 3P1546 Calibration Pin (3) in calibration hole.

4. Install the 5P6602 Adapter (7). Fasten it in position with a 1D4533 Bolt (5) and a 1D4538 Bolt (6).

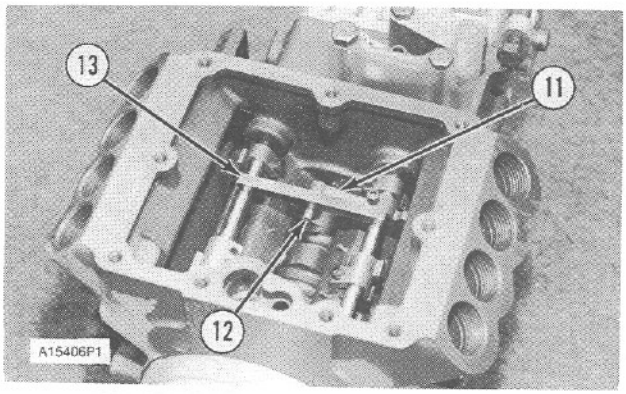
5. Put the 8S7271 Screw (4) (setscrew) in the hole over the calibration pin (3). Tighten the setscrew (4) to 2.3 to 2.8 N•m (20 to 25 lb in) with the 2P8264 Socket.

6. Adjust low idle screw (8) to position lever (9) to 8.9 ± 1.0 mm (.35 ± .04 in) from governor housing boss.



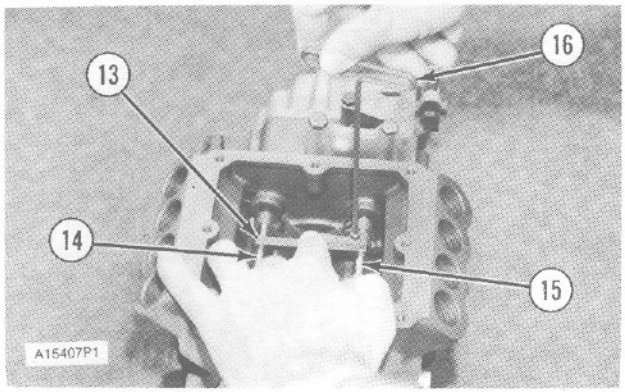
Crossover Levers
(10) Crossover lever. (11) Crossover lever. (12) Dowel pin.
(A) Sleeve levers.

7. Loosen the bolts that hold sleeve levers (A) and slide levers (A) out of the way.



5P4209 Gauge Installed
(11) Crossover lever. (12) Dowel pin. (13) 5P4209 Gauge.

8. Loosen the bolts that hold crossover lever (10) and (11) and move lever (10) off dowel pin (12).



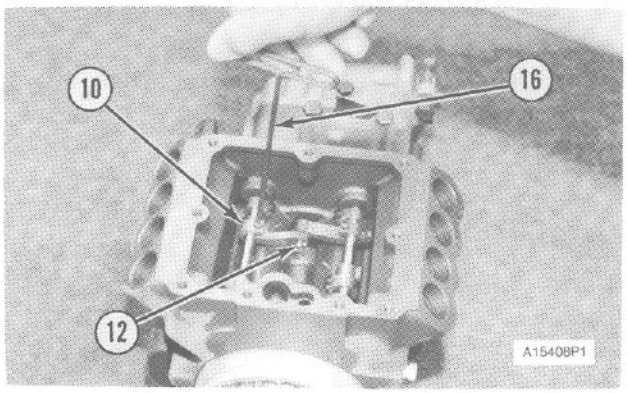
Adjustment Of Crossover Levers
(13) Gauge. (14) Shaft. (15) Shaft. (16) 5P4206 Wrench.

9. Put gauge (13) on shafts (14) and (15), put crossover lever (11) in a position so dowel pin (12) will fit in gauge hole. Hold gauge (13) down and torque the bolt that holds crossover lever (11) to 2.8 ± 0.2 N•m (24 ± 2 lb in).

10. Check adjustment again with the 5P4209 Gauge (13). Put gauge (13) on shafts (14) and (15), slide gauge toward crossover lever (11) to engage dowel pin (12) into hole in gauge (13).

11. If dowel pin (12) must be lifted to go into gauge, the lever must be adjusted again. If gauge (13) is lifted, a maximum of 0.20 mm (.008 in) clearance is acceptable under one side of gauge (13). Use a feeler gauge to check clearance.

12. Slide crossover lever (10) on to dowel pin (12). Torque the bolt that holds crossover lever (10) to 2.8 ± 0.2 N•m (24 ± 2 lb in).



Tightening Bolt
(10) Crossover lever. (12) Dowel pin. (16) Wrench.

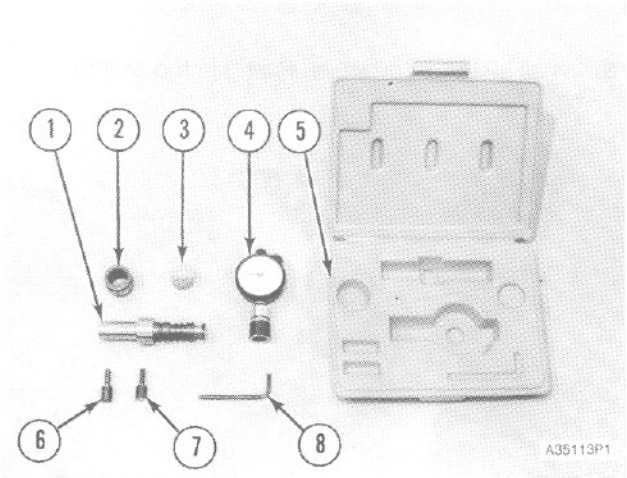
13. Check the adjustment again with the 5P4209 Gauge.

NOTE: After the adjustment of the crossover levers is completed, all of the fuel injection pumps must be calibrated. See Fuel Pump Calibration.

Fuel Pump Calibration

Tools Needed		
5P4203	Tool Group	1
8S2243	Wrench	1
5P6602	Adapter	1
5P4205	Wrench	1
1D4533	Bolt	1
1D4538	Bolt	1
8S7271	Screw	1
5P7253	Socket Assembly	1
5P4206	Wrench	1
6V0190	Clamp	1
3P2200	Sleeve Metering Calibration Tool Group	1

NOTE: 3P1540 Calibration pump must have the 5P6557 Spring installed instead of the 1P7377 Spring.



3P2200 Tool Group
(1) 3P1540 Calibration Pump. (2) 4N218 Bushing. (3) 1P7379 Microgauge. (4) 3P1568 Dial Indicator with 3P2226 Collet. (5) 5P6510 Box. (6) 3P1545 Calibration Pin with 17.3734 on it, (in-line engines). (7) 3P1546 Calibration Pin with 15.9410 on it. (Vee engines). (8) 1S9836 Wrench.

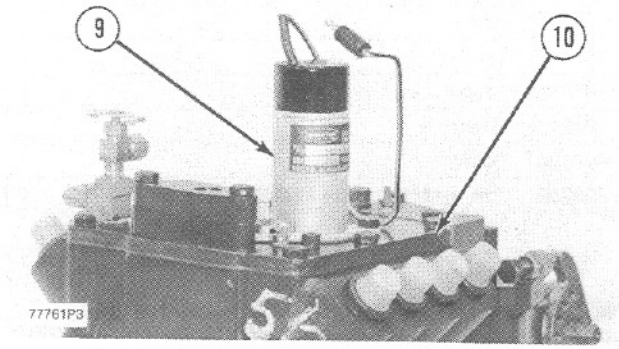
Checking Fuel Pump Calibration

The following procedure for fuel pump calibration can be done with the housing for the fuel injection pumps on or off the engine.

NOTICE
Before any service work is done on this fuel system, the outside of the injection pump housing and all parts connected to it must be clean.

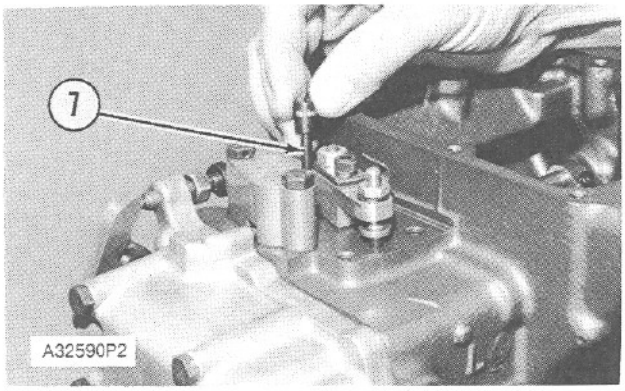
1. Remove the fuel shutoff solenoid (9), top cover (10) of the fuel pump housing and the cover over the torque control group.

2. Remove the fuel that is in the injection pump housing and the governor housing.



Removal Of Covers
(9) Shutoff solenoid. (10) Top cover.

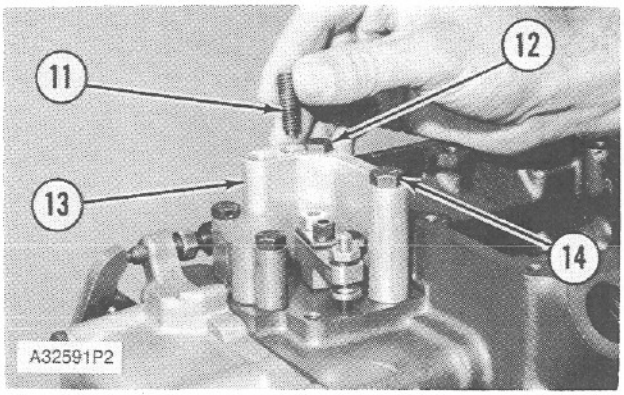
3. Install 3P1546 Calibration Pin (7) in the calibration hole.



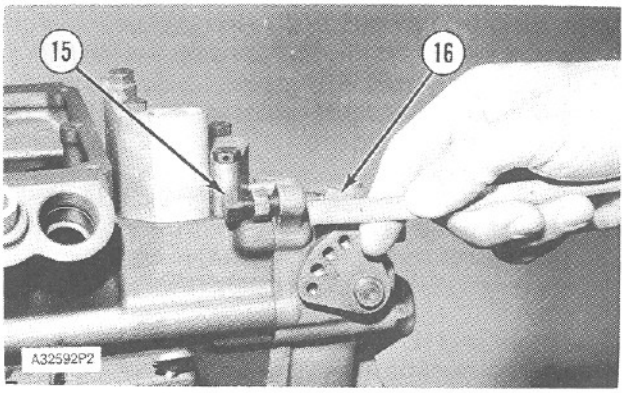
Installing Calibration Pin
(7) 3P1546 Calibration Pin with 15.9410 on it.

4. Install 5P6602 Adapter (13) as shown. Fasten it in position on the injection pump housing with a 1D4533 Bolt (12) and a 1D4538 Bolt (14).

5. Put 8S7271 Screw (11) in the hole over calibration pin (7). Tighten screw (11) to 2.3 to 2.8 N•m (20 to 25 lb in).



Installing 5P6602 Adapter And 8S7271 Screw
(11) Screw. (12) 1D4533 Bolt. (13) 5P6602 Adapter. (14) 1D4538 Bolt.



Adjustment Of Low Idle Screw
(15) Low idle screw. (16) Lever.

6. Adjust low idle screw (15) to position lever (16) to 8.9 ± 1.0 mm (.35 ± .04 in) from governor housing boss.

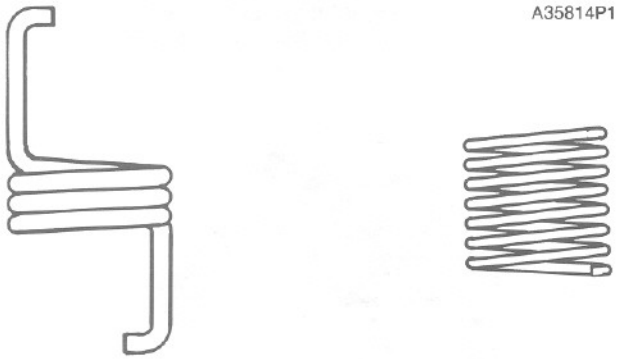
7. Use the 8S2243 Wrench and remove the fuel injection pumps to be checked.

NOTE: If pump is removed carefully, the sleeve will remain on the plunger. If the sleeve falls off the pump plunger during removal, find it immediately and replace it on the pump plunger before removal of another pump. The original sleeve must remain with the same pump plunger.

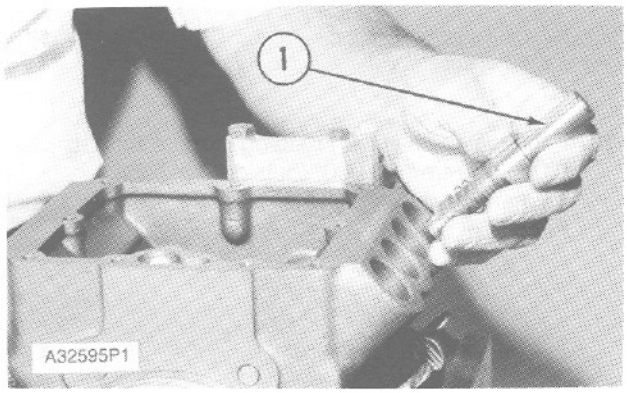
NOTE: When sleeve is installed on pump plunger, the narrower of the two lands on the sleeve must be toward top of pump (nearest the pump spring).

8. Clean the barrel and plunger of calibration pump (1). Put clean diesel fuel on the calibration pump for lubrication.

NOTE: Be sure that the spring on the calibration pump (1) is the 5P6557 Spring instead of the 1P7377 Spring which was installed on earlier calibration pumps.



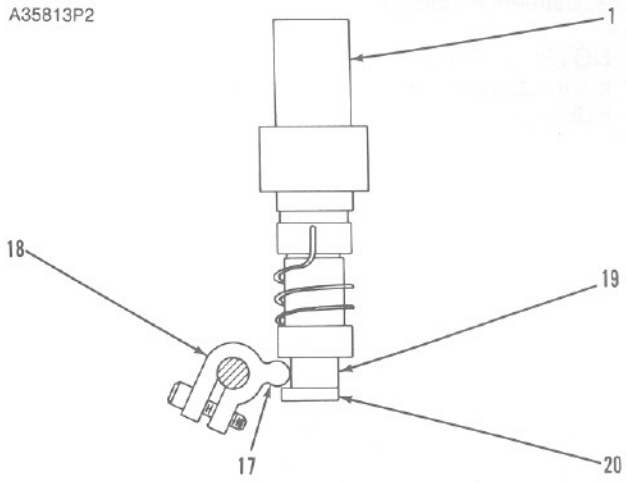
5P6557 Spring And 1P7377 Spring



Installing Calibration Pump
(1) 3P1540 Calibration Pump.

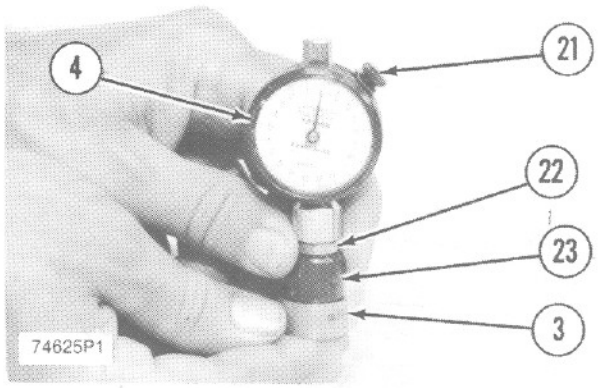
9. Put calibration pump (1) in the place of the pump to be checked with the flat place (20) on the plunger toward tang (17) on lever (18). When the calibration pump (1) is all the way in the bore, turn it 180° in either clockwise or counterclockwise direction. Tang (17) on lever (18) is now in groove (19) of calibration pump (1). Then install 4N218 Bushing (2). Use the 8S2243 Wrench and a torque wrench to tighten the bushing to 80 ± 7 N•m (60 ± 5 lb ft).

NOTE: Turning calibration pump (1) 180° gives the same reference point for all measurements.



Calibration Pump Installed
(1) 3P1540 Calibration Pump. (17) Tang on lever. (18) Lever. (19) Groove of calibration pump. (20) Flat on plunger.

NOTE: Use 4N0218 Bushing (2) and calibration pump (1) together. The contact surfaces of the standard bushing, fuel injection pump and the housing for the fuel injection pumps are sealing surfaces. Keep them clean and free of scratches to prevent leaks.



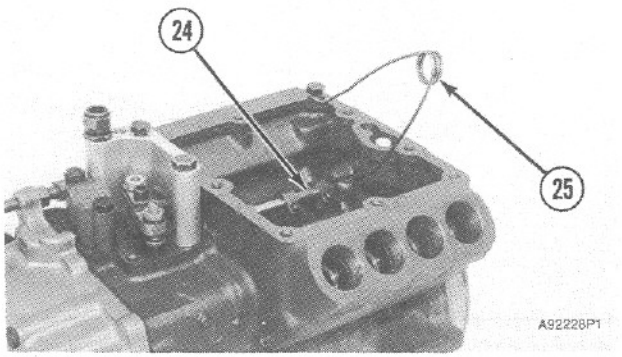
Putting Dial Indicator On Zero
(3) Microgauge. (4) 3P1568 Dial Indicator with 3P2226 Collet. (21) Lockscrew. (22) Locknut. (23) 3P2226 Collet.

10. Put dial indicator (4) on microgauge (3) and hold them together tightly. Loosen lockscrew (21) and turn the face of dial indicator (4) to put the pointer at "0". Tighten lockscrew (21).

Remove dial indicator (4) from microgauge (3). Look at the face of dial indicator (4) and put dial indicator (4) on microgauge (3) again. The pointer must move through one to one and one half revolutions before stopping at exactly "0". If the number of revolutions is not correct, loosen the locknut on 3P2226 Collet (23),

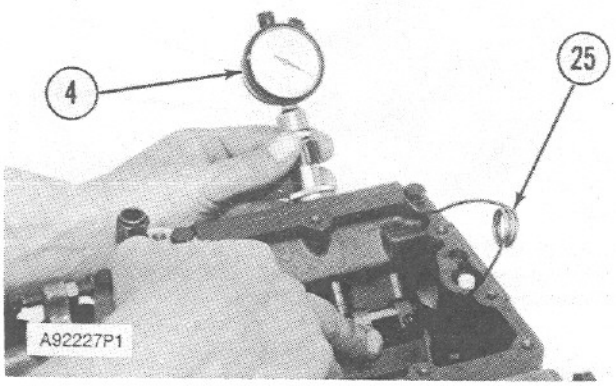
and adjust the position of the dial indicator until the adjustment is correct.

NOTE: If locknut (22) on the 3P2226 Collet is too tight, it can cause interference in the operation of the dial indicator.



6V0190 Clamp Installed
(24) Shaft. (25) 6V0190 Clamp.

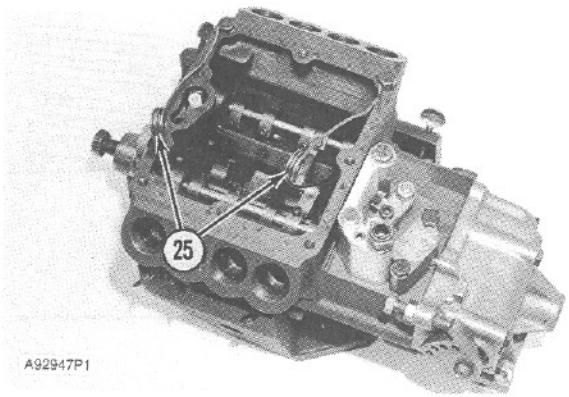
11. Put 6V0190 Clamp (25) in the position shown, next to the transfer pump end. Clamp (25) pushes shaft (24) down against the bottom of its bearing. The other end of shaft (24) is held down against its bearing by 3P1546 Calibration Pin (7) which is held by 8S7271 Screw (11). The combination of forces from clamp (25) and calibration pin (7) is necessary to hold shaft (24) is in its normal operating position against the lifting force from the spring in calibration pump (1).



Dial Indicator Position
(4) 3P1568 Dial Indicator with 3P2226 Collet. (25) Clamp.

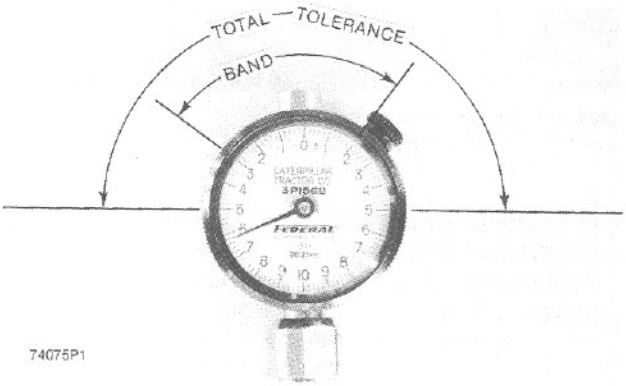
NOTE: When checking pumps on the "slave" side [side opposite from governor control lever (16)], put clamp (25) on both ends of sleeve shaft as shown.

12. Put dial indicator (4) on the calibration pump (1) as shown. Hold it tightly in place. Move shaft (24) toward the governor end to remove end play. To remove any clearance in the linkage, lift the crossover lever dowel and rapidly let it go. Do this several times. Then look at the reading on the dial indicator (4).



Installing Clamp On "Slave" Side
(25) 6V0190 Clamps.

13. If the dial indicator (4) reading is more than ± 0.050 mm from "0.000" (outside the Total Tolerance), do Steps 17 through 20, Adjusting Fuel Pump Calibration.



Dial Indicator Reading
Desired reading for all pumps is "0.000".

Maximum permissible tolerance for pump readings in any Fuel Injection Pump Group is 0.100 mm (-0.050 to +0.050 mm on dial indicator).

Maximum permissible differences between any two pumps in the same Fuel Injection Pump Group is 0.050 mm.

Total Tolerance shows the maximum permissible range of pointer positions which are acceptable. If any reading is outside the range of Total Tolerance, do Adjusting Fuel Pump Calibration for all pumps.

Band is an example only. It shows a 0.050 mm range. This range shows the maximum permissible difference between any two readings for all the pumps. If any two readings are farther apart than the 0.050 mm range, do Adjusting Fuel Pump Calibration for all pumps.

If the dial indicator (4) reading is near either end of the Total Tolerance, check another pump. If the next reading is outside the Total Tolerance or if the two readings have a difference of 0.050 mm or more, do the Steps 15 through 19, Adjustment Of Fuel Pump Calibration.

NOTE: The mechanic doing the checking must make the decisions of which and how many pumps to check according to the symptoms of the fuel injection pump being tested.

14. If dial indicator (4) readings for all the pumps are within the limits in Step 13, the calibration is acceptable. Remove the tooling, and install the parts which were removed.

NOTE: For troubleshooting purposes, if the dial indicator (4) reading is "0" or near "0", the calibration of the other pumps is probably in the tolerance.

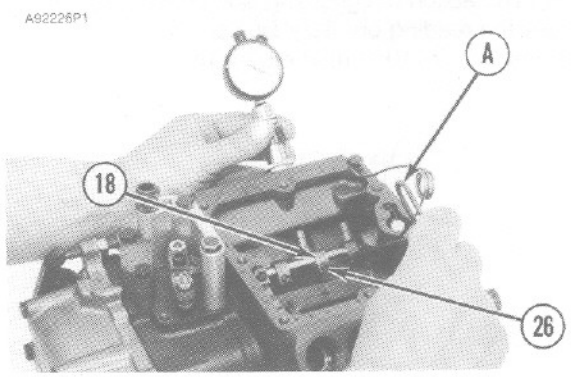
Adjustment of Fuel Pump Calibration

15. Remove all pumps with 8S2243 Wrench.

16. Clean the barrel and pump of calibration pump (1). Put clean diesel fuel on the calibration pump (1) for lubrication.

17. Install calibration pump (1) in the place of one of the pumps according to the procedure in Step 9.

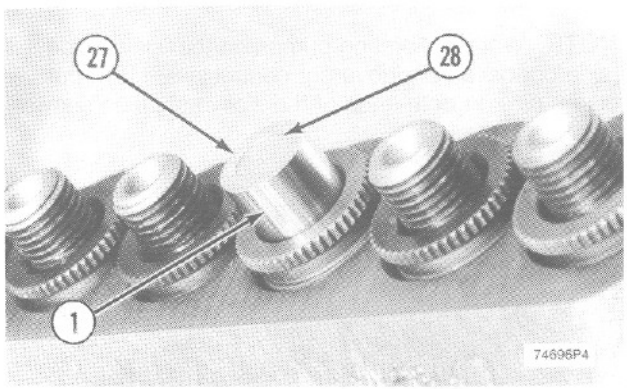
18. Loosen bolt (26) with 1S9836 Wrench (8) or 5P4206 Wrench. Turn the lever (18) on shaft (24) enough to move the top of plunger (28) of calibration pump (1) below top surface (27) of calibration pump (1). Tighten bolt (26) just enough for lever (18) to hold plunger (28) stationary.



5P4206 Wrench
(18) Lever. (26) Bolt. (A) 5P4206 Wrench.

NOTE: When bolt (26) has the correct torque, pushing with a small amount of force on lever (18) through the wrench moves plunger (28) in calibration pump (1).

19. Move shaft (24) toward the governor to remove end play. Then push down on lever (18) through the wrench until top of plunger (28) is almost even with top surface (27) of calibration pump (1) as shown.

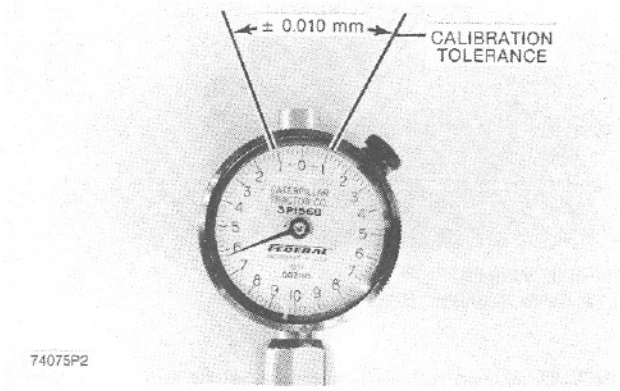


Plunger Position
(1) Calibration pump. (27) Top surface of calibration pump. (28) Plunger.

20. Check dial indicator (4) according to Step 10. Then put dial indicator (4) in place over the center of calibration pump (1) and hold it there tightly. Now move plunger (28) of calibration pump (1) by pushing on lever (18) through the wrench. Stop moving the plunger when the dial indicator is at approximately 0.009 mm past "0.000". Tighten bolt (26) to 2.8 ± 0.2 N•m (24 ± 2 lb in).

NOTE: When moving plunger (28), make sure that the last direction of plunger (28) movement is in the up direction. If plunger (28) goes up too far, move plunger (28) down to a position below that desired. Then move plunger (28) up to the desired position.

NOTE: The action of tightening bolt (26) usually changes the reading on dial indicator (4) by approximately (0.010 mm) in the minus direction.

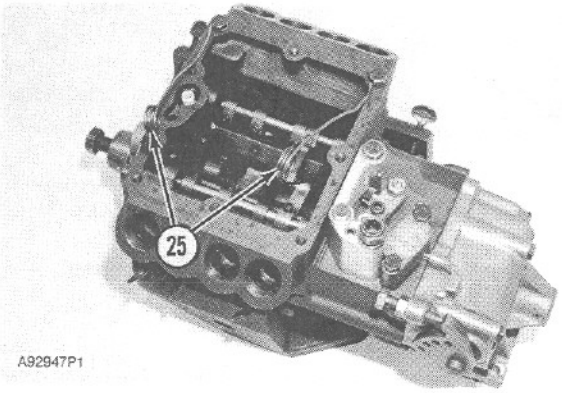


± 0.010 mm Calibration Tolerance

Move shaft (24) toward shutoff several times to remove clearance in the linkage. Dial indicator (4) reading must be (0.000 ± 0.010 mm) as shown.

When the pump calibration is correct make a record and then do the same procedure for all the other pumps.

NOTE: When calibrating pumps on the "slave" side [side opposite from governor control lever (16)], put clamp (25) on both ends of the sleeve shaft as shown.



Installing Clamp On "Slave" Side
(25) 6V0190 Clamps.

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.

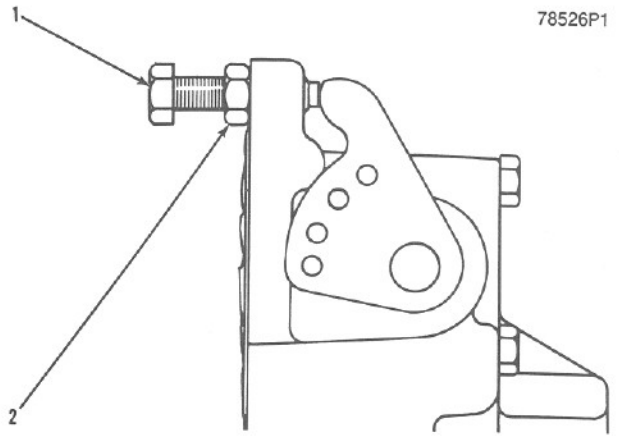
Low Idle Adjustment

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

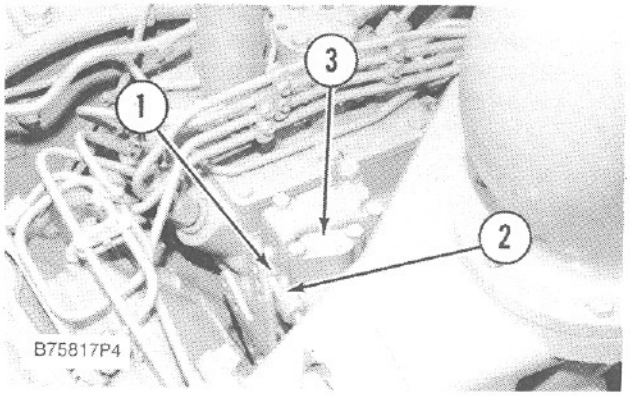
⚠ WARNING

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

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



Adjustment Of Low Idle RPM
(1) Adjustment bolt for low idle. (2) Locknut.



Adjustment Of Low Idle RPM
(1) Adjustment bolt for low idle. (2) Locknut. (3) Cover.

To adjust the LOW IDLE rpm, start the engine and run with the governor in the low idle position.

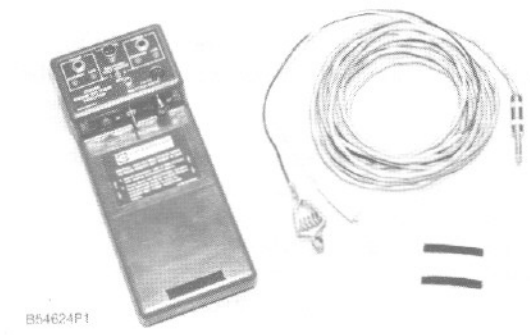
Loosen locknut (2) for low idle screw (1). Turn the low idle screw to get the correct low idle rpm. Increase engine speed and return to low idle and check low idle speed again. Tighten the locknut.

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		
6V4060	Engine Set Point Indicator Group	1



6V4060 Engine Set Point Indicator Group

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

Alternate Method

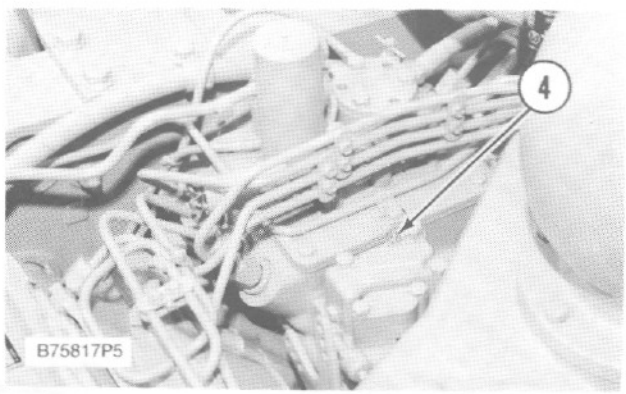
Tools Needed		
8T0500	Circuit Tester	1
6V3121	Multitach Group	1

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 and stop or first torque spring just make contact.

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

1. Connect a tachometer which has good accuracy to the tachometer drive.
2. Connect the clip end of the 8T0500 Circuit Tester to the brass terminal screw (4) on the governor housing. Connect the other end of the tester to a place on the fuel system which is a good ground connection.



Terminal Location
(4) Brass terminal screw.

⚠ WARNING

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

3. Start the engine.
4. With the engine at normal conditions for operation, run the engine at high idle.
5. Make a record of the speed of the engine at high idle.

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

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

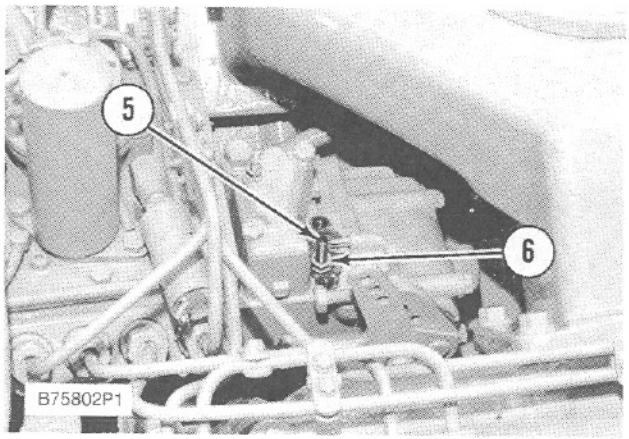
8. Repeat Step 6 several times to make sure that the reading is correct.

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

NOTE: It is possible in some applications that the high idle rpm will be less than the 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.



Adjustment Of Set Point
(5) Adjustment screw. (6) Locknut.

2. If the set point rpm is not correct, remove cover (3) and loosen locknut (6). Turn adjustment screw (5) to adjust the set point to the mid point of the tolerance.

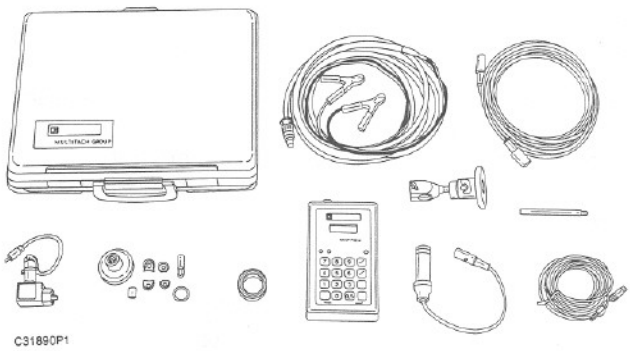
3. When the set point is correct, check the high idle rpm. The high idle rpm must not be more than the high limit of the tolerance.

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.

Engine Speed Measurement

Tools Needed		
6V3121	Multitach Group or	1
6V4950	Injection Line Speed Pickup Group	1

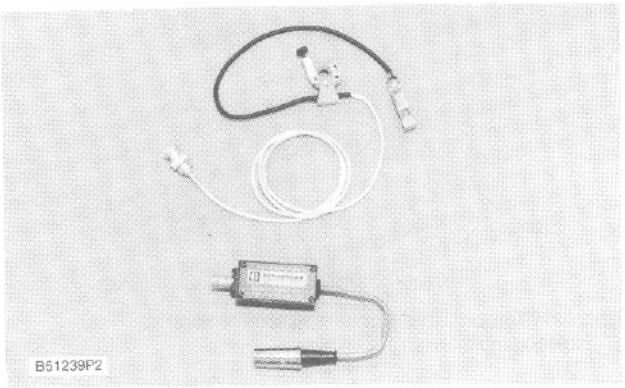
The 6V3121 Multitach Group can measure engine speed from a tachometer drive on the engine. It also has the ability to measure engine speed from visual engine parts in rotation.



6V3121 Multitach Group

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

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.



6V4950 Injection Line Speed Pickup Group

Special Instruction, Form No. SEHS8029 is with the group and gives instructions for use of the 6V4950 Injection Line Speed Pickup Group.

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 of more than 635 mm (25 in) of water difference in pressure.

Back pressure from the exhaust (pressure difference measurement between exhaust outlet elbow and atmosphere) must not be more than 686 mm (27 in) of water.

Measurement Of Pressure In Inlet Manifold

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

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

a. 747 mm (29.4 in) of mercury barometric pressure.

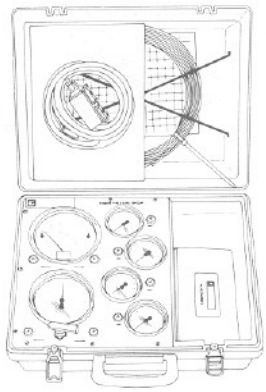
b. 229°C (85°F) outside air temperature.

c. 35 API rated fuel.

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

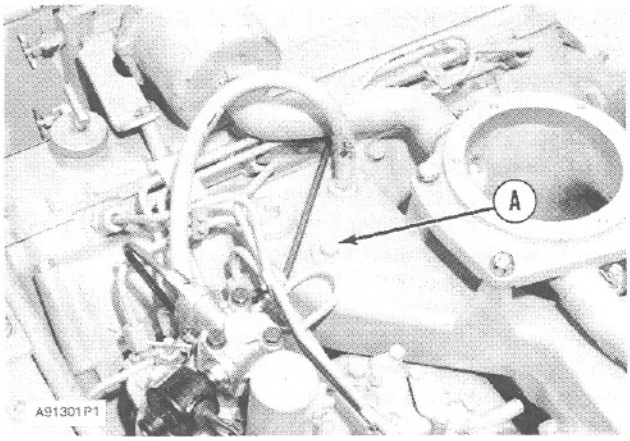
A difference in fuel rating will also change horsepower and the pressure in the inlet manifold. If the fuel is rated above 35 API, pressure in the inlet manifold can be less than given in the Fuel Setting And Related Information Fiche. If the fuel is rated below 35 API, the pressure in the inlet manifold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

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

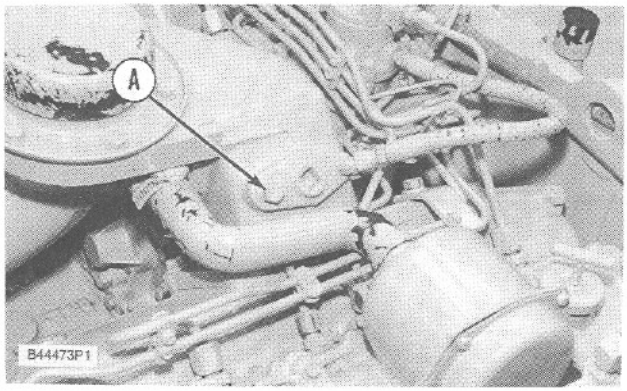


1U5470 Engine Pressure Group

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



Location For Pressure Test
(A) Remove fitting and install test fitting.



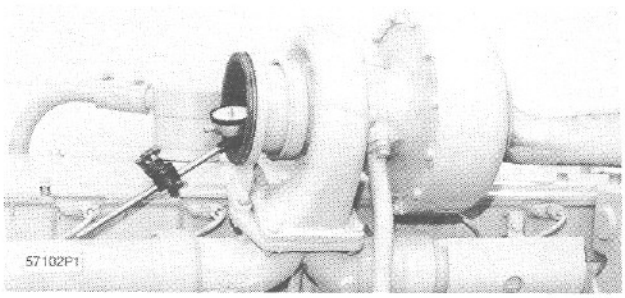
Location For Pressure Test
(A) Remove fitting and install test fitting.

Turbocharger

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

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

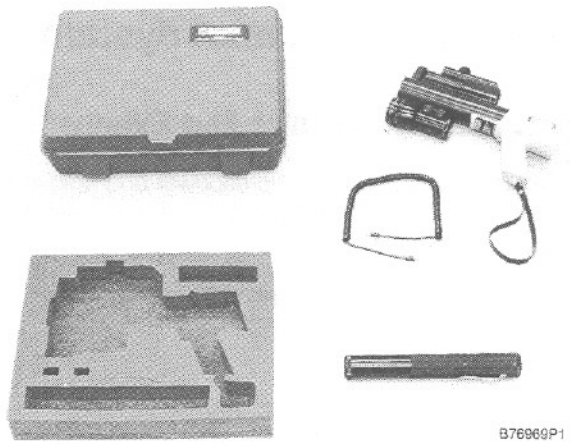
For the correct end play for the turbochargers see the Specifications Section. If end play is more than the maximum end play rebuild or replace the turbocharger. End play less than the minimum end play could indicate carbon build up on the turbine wheel and should be disassembled for cleaning and inspection.



Checking Turbocharger Rotating Assembly End Play
(Typical Example)

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

Exhaust Temperature



6V5000 Infrared Thermometer Group

Use the 6V5000 Infrared Thermometer Group to check exhaust temperature. Special Instruction, Form No. SEHS8149 is with the tool group and gives instructions for the test procedure.

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 gauges 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 13.5 kPa (4 in Hg), the air lines and cooler core must be inspected for internal restriction and cleaned, repaired or replaced as necessary.

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.

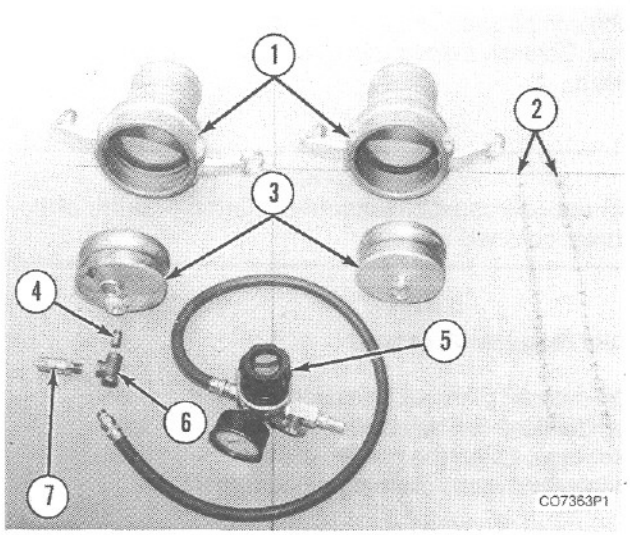
Inlet Manifold Pressure

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 temperatures 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 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



FT1984 Air To Air Aftercooler Test Group
(1) Coupler. (2) Chain. (3) Dust plugs. (4) Nipple. (5) Regulator and valve assembly. (6) Tee. (7) Relief valve.

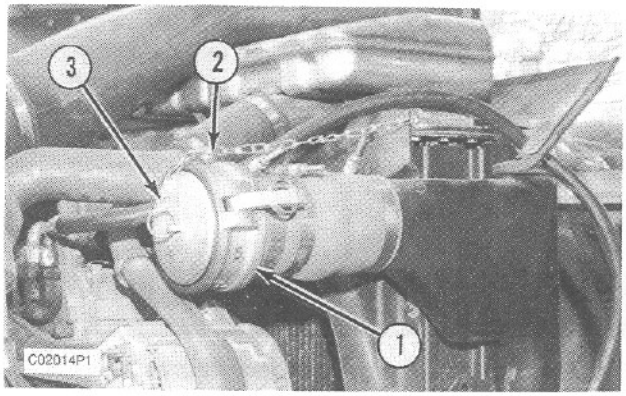
A low power problem in the engine can be the result of aftercooler leakage. Low power, low boost pressure, black smoke, and/or high exhaust temperature can be the result of an aftercooler system leakage.

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.

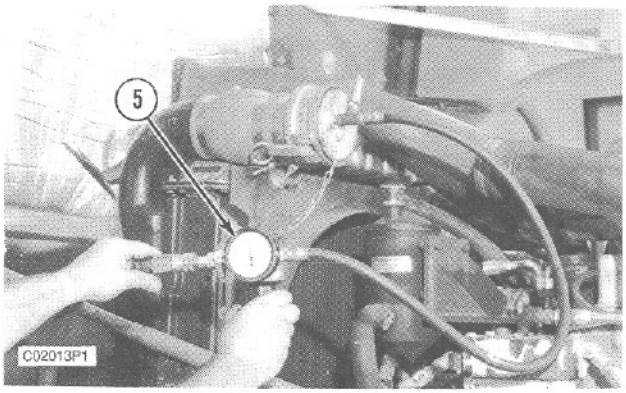


Tooling Installed
(1) Coupler. (2) Chain. (3) Dust plugs.

2. Install couplers (1) and dust plugs (3) from the FT1984 Air to Air Aftercooler Test Group as shown onn each side of the aftercooler core. Installation of additional hose clamps on hump hoes is recommended to prevent the hoses from bulging while the aftercooler core is being pressurized.

⚠ WARNING

Dust plug chains (2) 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.



Pressurize System
(5) Regulator and valve assembly.

3. Install regulator and valve assembly (5) 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 (5).

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.

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).

Cylinder Compression

An engine that runs rough can have a leak at the valves, or valves that need adjustment. Run the engine at the speed that gives rough running. To find a cylinder that has low compression or does not have good fuel ignition, loosen a 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 rough running. Be sure to tighten each fuel line nut after the test before the next fuel line nut is loosened. This test can also be an indication that the fuel injection is wrong, so more checking of the cylinder will be needed.

An analysis of the engine cylinder condition can be done with controlled pressure air through the cylinder head. Special Instruction, Form No. GMG00694 explains the procedure.

1. Remove the fuel injection nozzle.

2. Adapt an air hose to 1P5564 Adapter. Install the 1P5564 Adapter in the fuel injection nozzle opening in the cylinder head.

3. Start crankshaft rotation until the piston in the cylinder being inspected is at TC on the compression stroke. In this position, the valves of this cylinder will be against their seats.

4. Force the air into the cylinder and then check for air leakage. An air leak from the exhaust opening is an indication of exhaust valve leakage and an air leak from the air cleaner inlet is an indication of intake valve leakage. If the air leakage is into the crankcase during this test, the piston or piston rings can be the cause.

Valve Clearance Setting

Check and adjust the valve clearance with engine stopped.

Valve clearance is measured with a thickness gauge between the top of the valve stem and the rocker arm.

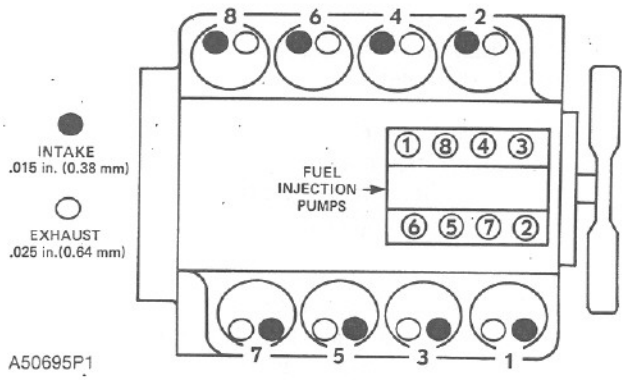
Valve Clearance Check: Engine Stopped
Exhaust ... 0.56 to 0.71 mm (.022 to .028 in) Intake ... 0.30 to 0.46 mm (.012 to .018 in)

NOTE: When the valve lash (clearance) is checked, adjustment is NOT NECESSARY if the measurement is in the range given in the chart for VALVE CLEARANCE CHECK: ENGINE STOPPED. If the measurement is outside this range, adjustment is necessary. See the chart for VALVE CLEARANCE SETTING: ENGINE STOPPED, and make the setting to the nominal (desired) specifications in this chart.

Valve Clearance Setting: Engine Stopped
Exhaust ... 0.64 mm (.025 in) Intake ... 0.38 mm (.015 in)

To check and make adjustment to the valve lash, use the procedure that follows:

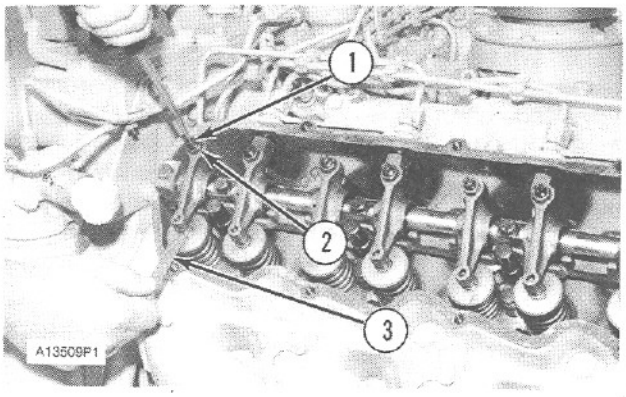
1. Remove the valve covers.



Cylinder, Valve And Pump Location

2. Turn the crankshaft COUNTERCLOCKWISE (as seen from rear of engine) until No. 1 piston is at top center on the compression stroke. The TDC-1 mark on the damper assembly will be in alignment with the timing pointer.

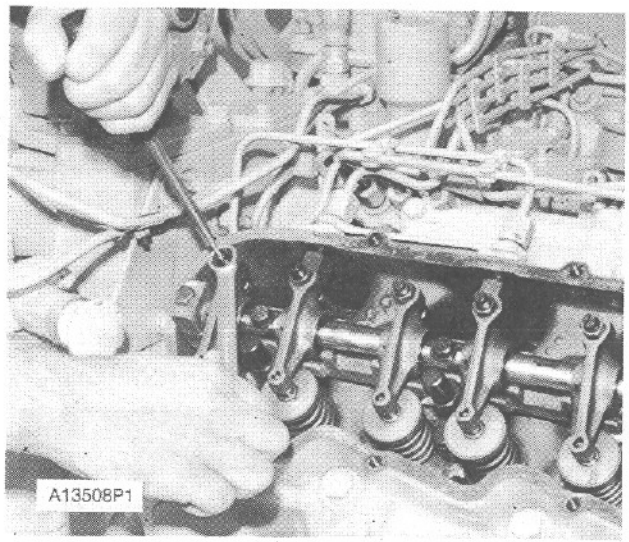
3. Make adjustment to the valves for No. 1 and No. 2 cylinders. To make the adjustment, loosen locknut (2). Turn the adjustment screw (1) until the feeler gauge (3) will go between the end of the valve stem and the rocker arm.



Valve Lash Adjustment
(1) Adjustment screw. (2) Locknut. (3) Feeler gauge.

4. After the adjustment is complete, hold adjustment screw (1) and tighten locknut (2) to 32 ± 7 N•m (24 ± 5 lb ft). After the locknut is tightened, check the adjustment again.

5. Turn the crankshaft 180° COUNTERCLOCKWISE (as seen from rear of engine). The VS mark on the damper assembly will be in alignment with the timing pointer. Make adjustment to the valves for No. 3 and No. 7 cylinders.



Tightening Locknut

6. Turn the crankshaft 180° COUNTERCLOCKWISE (as seen from rear of engine). The TDC-1 mark on the damper assembly will be in alignment with the timing pointer. Make adjustment to the valves for No. 4 and No. 5 cylinders.

7. Turn the crankshaft 180° COUNTERCLOCKWISE (as seen from rear of engine). The VS mark on damper assembly will be in alignment with the timing pointer. Make adjustment to the valves for No. 6 and No. 8 cylinders.

When the adjustment of the valve lash needs to be done several times in a short period of time, it can be an indication of wear in a different part of the engine. Find the problem and make any necessary repairs to prevent more damage to the engine.

Not enough valve lash, if not corrected, can be the cause of rapid wear of the camshaft and cam followers. Not enough valve lash can also be an indication of the seats for the valves being bad. Some reasons for the seats for the valves becoming bad are fuel injection nozzles with defects, restrictions to the inlet air or dirty air filters, wrong fuel setting, or using the engine on loads that are too large for the engine.

Too much valve lash, if not corrected, can be the cause for broken valve stems, push rods, or spring retainers. A fast increase in valve lash can be an indication of any of the following:

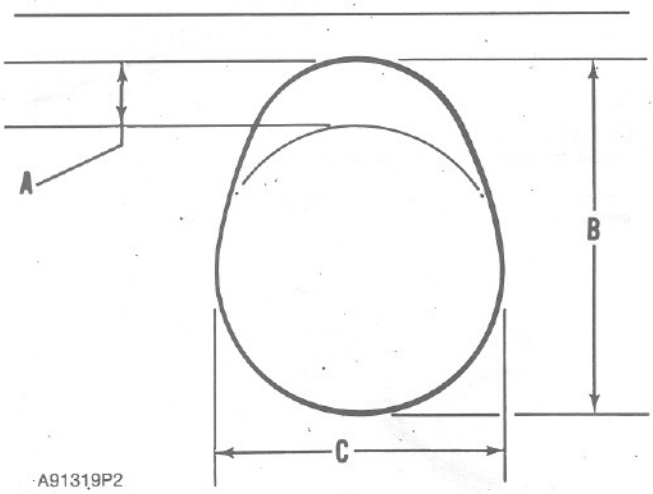
a. Camshaft and cam follower with wear.
b. Rocker arms with wear.
c. Push rods that are bent.
d. Loose adjustment screw for the valve lash.
e. Broken socket on the upper end of the push rod.

If the camshaft and cam followers show signs of rapid wear, look for fuel in the lubrication oil or dirty lubrication oil as a possible cause when making the necessary repairs.

Procedure For Measuring Camshaft Lobes

To find lobe lift (A) of camshaft, use the procedure that follows:

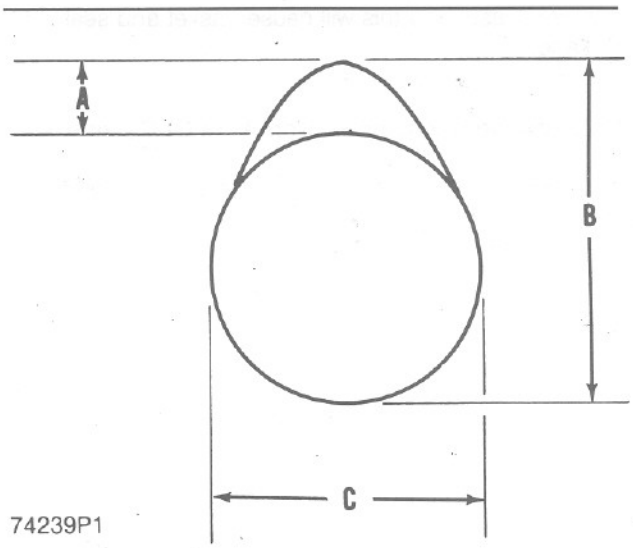
1. Measurement lobe height (B) of one exhaust and one intake lobe.
2. Measure base circle (C) of one exhaust and one intake lobe.
3. Subtract base circle (C) dimension (Step 2) from lobe height (B) dimension (Step 1). The difference is actual lobe lift (A).
4. The specified (new) lobe lift (A) is:



Camshaft Lobe (Roller Lifters)
(A) Lobe lift. (B) Lobe height. (C) Base circle.

Camshaft with Roller Lifters:

(a) Exhaust lobe ..... 9.40 mm (.370 in)
(b) Intake lobe ..... 9.33 mm (.367 in)



Camshaft Lobe (Flat Face Lifters)
(A) Lobe lift. (B) Lobe height. (C) Base circle.

Camshaft with Flat Face Lifters:

(a) Exhaust lobe ..... 9.40 mm (.370 in)
(b) Intake lobe ..... 9.06 mm (.357 in)

5. The maximum permissible difference between actual lobe lift (Step 3) and specified lobe lift (Step 4) is 0.25 mm (.010 in).

Lubrication System

One of the problems in the following list 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 is coming 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 not installed correctly.
4. Oil leakage past the seal rings in the impeller end of the turbocharger shaft.

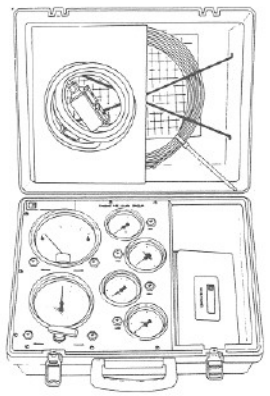
Too much oil consumption can also be the result of using oil with the wrong viscosity. Oil with a thin (low) viscosity can be caused from dirt or fuel getting in the crankcase, or by the engine getting too hot.

Measuring Engine Oil Pressure

Tools Needed		
1U5470	Engine Pressure Group	1

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

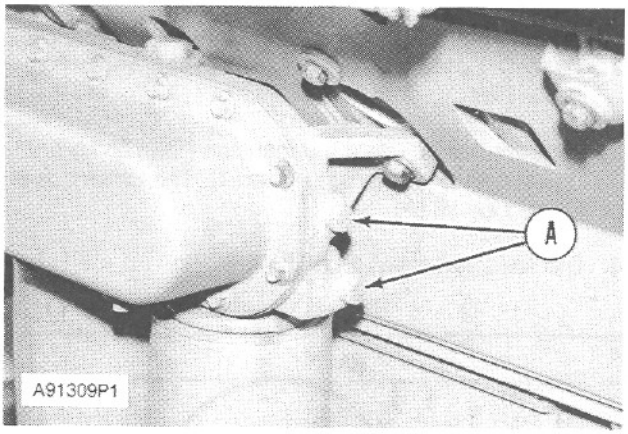
The 1U5470 Engine Pressure Group can be used to check engine oil pressure.



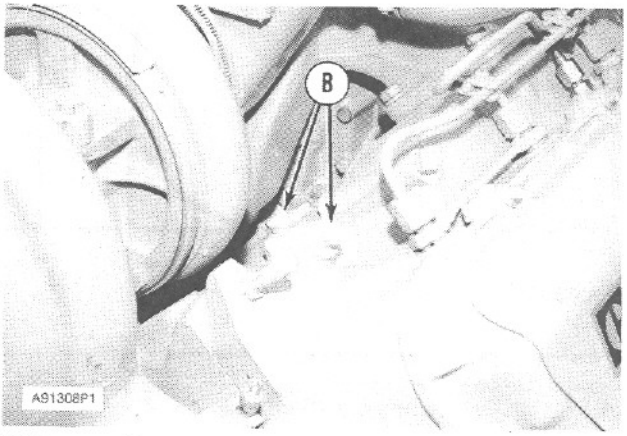
1U5470 Engine Pressure Group

This tool group has a gauge to read oil pressure in the engine. Special Instruction, Form No. SEHS8524 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 10W30 oil. If any other viscosity of oil is used, the information in the Engine Oil Pressure Chart does not apply.
2. Connect the 1U5470 Engine Pressure Group to the main oil manifold at location (A) or location (B).



Oil Pressure Test Location
(A) Oil pressure test location at oil cooler.



Oil Pressure Test Location
(B) Oil pressure test location at rear of right cylinder head.

3. Run the engine to get the oil temperature at 93 ± 6°C (200 ± 10°F).
4. Keep the oil temperature constant with the engine at the rated rpm from the chart, and read the pressure gauge.

Engine Oil Pressure At 2800 RPM SAE 10W30 Oil at 93 ± 6°C (200 ± 10°F)	
Test Location	Pressure
A	380 to 550 kPa (55 to 80 psi)
B	345 to 520 kPa (50 to 75 psi)

If the results do not fall within the pressure range given in the chart, 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 pressure outside this range.

Oil Pressure Is Low

Crankcase Oil Level

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

Oil Pump Does Not Work Correctly

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

Oil Filter and Oil Cooler

A dirty oil filter will cause a reduction in oil pressure. When the oil filter is filled with dirt, a restriction of oil flow through the filter and a reduction of filtered oil pressure is the result.

The bypass valve will cause the flow of oil to go around the filter elements when there is a reduction to the flow through the elements. When the bypass valve is open, oil that is not filtered is permitted to flow through the engine. To correct this problem, install a new Caterpillar filter.

Look for a restriction in the oil passages of the oil cooler. If the oil cooler has a restriction, the oil cooler bypass valve in the oil filter base will open. This will cause the flow of oil to go around the oil cooler. The oil temperature will be higher than normal when the engine is running. The oil pressure of the engine will become low if the oil cooler has a restriction.

Too Much Clearance at Engine Bearings or Open, Broken or Disconnected Oil Line or Passage in Lubrication System

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.

Oil Pressure Is High

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

Too Much Bearing Wear

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

If the gauge for oil pressure shows the correct oil pressure, but a component is worn because it is not getting enough lubrication, look at the passage for oil supply to that 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 oil cooler. If the oil cooler has a restriction, the oil temperature will be higher than normal when the engine is operated. The oil pressure of the engine will not get low just because the oil cooler has a restriction.

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

Cooling System

The cooling system is a pressure type with regulators at the outlet, the cooling system is equipped with a shunt line.

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.
3. Look for bent radiator fins. Be sure that air flow through the radiator does not have a restriction.
4. Inspect the drive belt 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 pressure cap and the sealing surface for the cap. The sealing surface must be clean.

Testing The Cooling System

Remember than temperature and pressure work together. When making a diagnosis 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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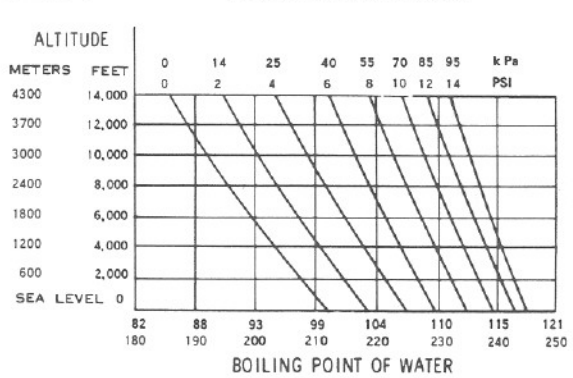
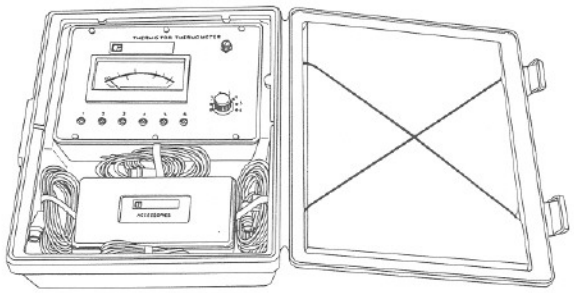


Tools Needed		
8T0470	Thermistor Thermometer Group	1
8T2700	8T2700 Blowby/Air Flow Indicator Group	1
6V3121	6V3121 Multitach Group	1
9S8140	Cooling System Pressurizing Pump Group	1

The 8T0470 Thermistor Thermometer Group is used in the diagnosis of overheating (engine hotter than normal) or overcooling (engine cooler than normal) problems. This group can be used to check temperatures in several different parts of the cooling system. The testing procedure is in Special Instruction, Form No. SEHS8446.



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8T0470 Thermistor Thermometer Group

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

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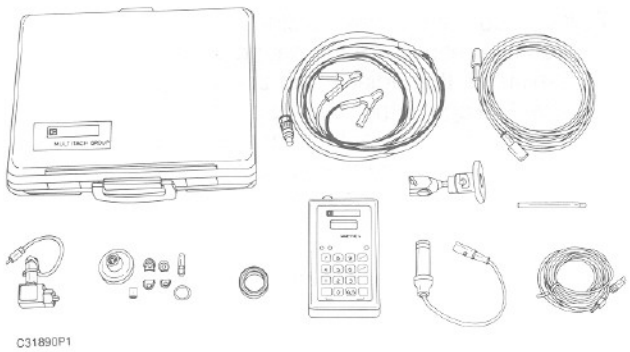
8T2700 Blowby/Air Flow Indicator Group

The 6V3121 Multitach Group is used to check the fan speed. The testing procedure is in Special Instruction, Form No. SEHS7807.



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6V3121 Multitach Group

Pressure Cap Test

Tools Needed		
9S8140	Cooling System Pressurizing Pump Group	1

One cause for a pressure loss in the cooling system can be a bad seal on the pressure cap of the system. 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, valve, 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.

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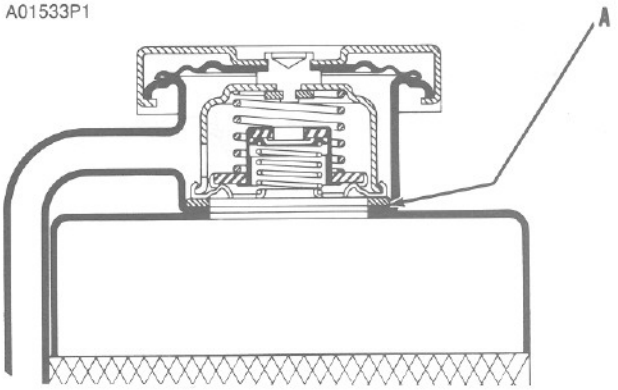


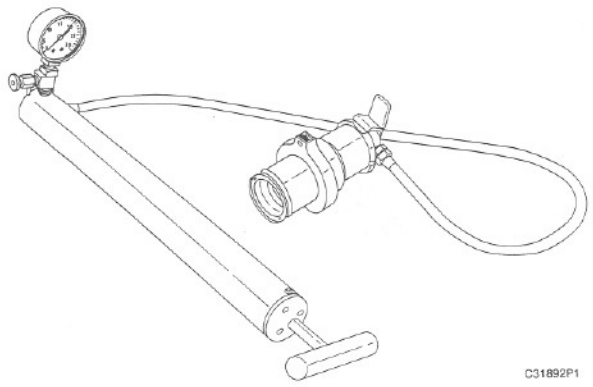
Typical Schematic Of Pressure Cap
(A) Sealing surface of cap and radiator.

To check the pressure cap for the pressure that makes the pressure cap open, 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. After the engine is cool, loosen the pressure cap to the first stop and let the pressure out of the cooling system. Then remove the pressure cap.
2. Put the pressure cap on the 9S8140 Cooling System Pressurizing Pump Group.



9S8140 Cooling System Pressurizing Pump Group

3. Look at the gauge for the exact pressure that makes the pressure cap open.
4. Make a comparison of the reading on the gauge with the correct pressure at which the pressure cap must open.

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

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

Radiator and Cooling System Leak Tests (Systems That Use Pressure Cap)

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. After the engine is cool, loosen the pressure cap to the first stop and let the pressure out of the cooling system. Then remove the pressure cap.
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. Get the pressure reading on the gauge to 20 kPa (3 psi) more than the pressure on the pressure cap.
5. Check the radiator for outside leakage.
6. Check all connections and hoses for the cooling system for outside leakage.
7. If you do not see any outside leakage and the pressure reading on the gauge is still the same after 5 minutes, the radiator and cooling system do not have leakage. If the reading on the gauge goes down and you do not see any outside leakage, there is leakage on the inside of the cooling system. Make repairs as necessary.

Gauge for Water Temperature

Tools Needed		
8T0470	Thermistor Thermometer Group	1

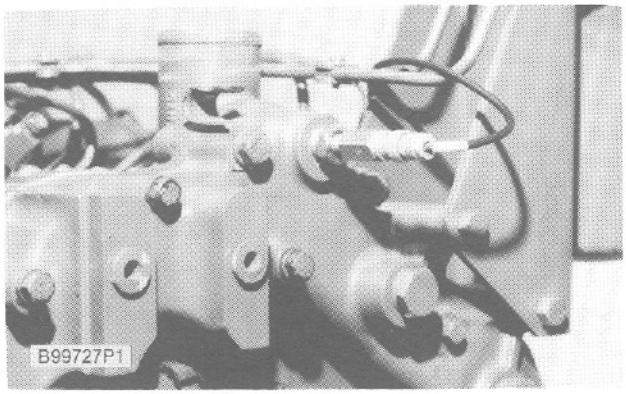
If the engine gets too hot and a loss of coolant is a problem, a pressure loss in the cooling system can be the cause. If the gauge for water temperature shows that the engine is getting too hot, look for coolant leakage.

If a place can not be found where there is coolant leakage, check the accuracy of the gauge for water temperature. Use the 8T0470 Thermistor Thermometer Group.

⚠ WARNING

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

Start the engine. Put a cover over part of the radiator. The reading on the gauge for water temperature must be the same as the reading on the thermistor thermometer.



8T0470 Thermistor Thermometer Group Installed
(Typical Example)

Temperature Regulator

Test procedure for water temperature regulators:

1. Remove the regulator from the engine.
2. Heat a pan of water to a temperature of 92°C (197°F).
3. Hang the regulator in the pan of hot water. Put the regulator completely under water. Do not let the regulator make contact with the pan.
4. Keep the temperature of the water at 92°C (197°F) for ten minutes. Make sure the water moves around. This keeps all of the water at the same temperature.
5. After ten minutes, remove the regulator and immediately measure the distance the regulator is opened. The distance must not be less than 37.85 mm (1.490 in).

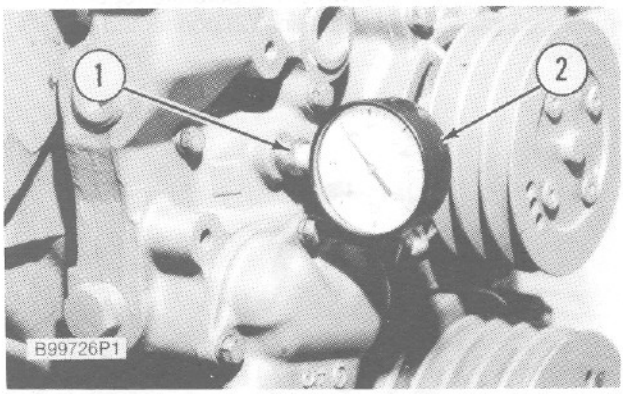
Water Pump Pressure Check

Tools Needed		
9S8138	Pressure Gauge	1
3B7722	Bushing	1

The pressure at the outlet for the water pump tells if the shunt system and water pump are operating correctly. To check the pump pressure, install pressure gauge (2) in the front cover. The pressure must be a minimum of 105 kPa (15 psi) at 2800 rpm.

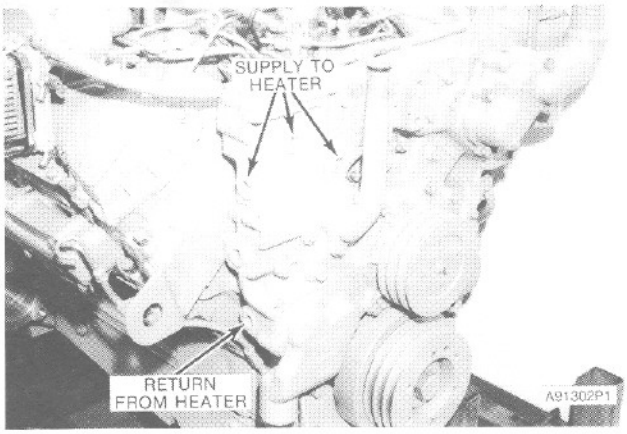
If the pump pressure is less than the minimum pressure: First, check the vent tube between the radiator top tank and the surge tank; it must have an inside diameter of approximately 4.8 mm (.19 in).

Second check to see that the shunt line has a minimum inside diameter of 19.1 mm (.75 in).



Gauge Installed
(Typical Example)
(1) 3B7722 Bushing. (2) 9S8138 Pressure Gauge.

Heater Connections

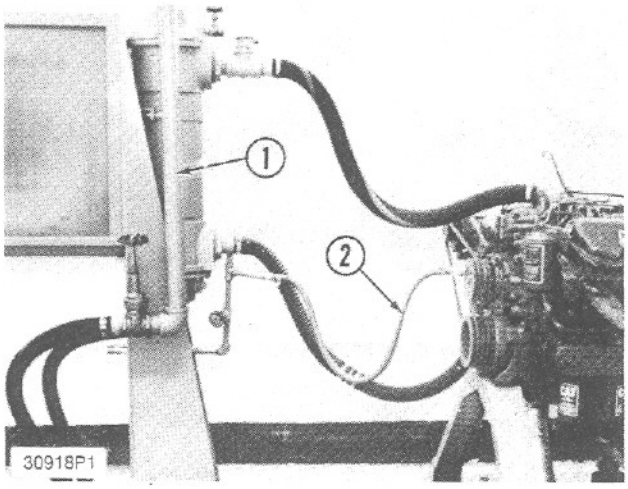


Locations Of Heater Connections

The front housing has several plugs that give access to water passages inside the housing. For the correct access points to install heater hoses, see the Locations Of Heater Connections picture.

Dynamometer Test Caution

To prevent possible damage to an engine while testing on a dynamometer, the water temperature regulators must be installed and shunt line (2) connected as shown.



Shunt Line Connected To Engine
(Typical Example)
(1) FT0790 Cooling Tower Group. (2) Shunt line.

BELT TENSION CHART										
BELT SIZE	WIDTH BELT TOP		WIDTH TOP OF PULLEY GROOVE		BELT TENSION "INITIAL"*		BELT TENSION "USED"**		BORROUGHS GAUGE NUMBERS	
					GAUGE READING		GAUGE READING			
	mm	in.	mm	in.	N	lb	N	lb	OLD GAUGE NO.	NEW GAUGE NO.
3/8	10.72	.422	9.65	.380	445 ± 22	100 ± 5	400 ± 22	90 ± 5	BT-33-95	BT-33-97
1/2	13.89	.547	12.70	.500	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-95	BT-33-97
5V	15.88	.625	15.24	.600	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
11/16	17.48	.688	15.88	.625	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
3/4	19.05	.750	17.53	.690	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
15/16	23.83	.983	22.30	.878	534 ± 22	120 ± 5	400 ± 44	90 ± 10	BT-33-72-4-15	BT-33-72C
8K	27.92	1.099			800 ± 22	180 ± 5	489 ± 44	110 ± 10		BT-33-109
MEASURE TENSION OF BELT FARTHEST FROM THE ENGINE										
*"INITIAL" BELT TENSION is for a new belt. **"USED" BELT TENSION is for a belt which has more than 30 minutes of operation at rated speed of engine. A10232-4P1										

Basic Block

Connecting Rods And Pistons

Use the 5F9059 Piston Ring Expander to remove or install piston rings.

Use the 5P3524 Piston Ring Compressor to install pistons into ccylinder block.

Tighten the connecting rod nuts in the following step sequence:

1. Put 2P2506 Thread Lubricnt on bolt threads and seating surfaces of cap and nut.
2. Tighten both nuts to 40 ± 4 N•m (30 ± 3 lb ft).
3. Put a mark on each nut and cap.
4. Tighten each nut 60° from the mark.

The connecting rod bearings should fit tightly in the bore in the rod. If bearing joints or backs are worn (fretted), check for bore size as this is an indication of wear because of looseness.

5P3519 Piston Ring Groove Gauge

A 5P3519 Piston Ring Groove Gauge is available for checking rectangular ring grooves. For instructions on the use of the gauge, see the Guideline For Reusable Parts; Pistons And Cylinder Liners, Form No. SEBF8001.

NOTE: The 5P3519 Piston Ring Groove Gauge is used to check the top ring groove only.

Piston Ring Groove Gauge

5P3519 PISTON RING GROOVE REUSABILITY GAUGE

BORE SIZE	GAUGE NUMBER	
	TOP GROOVE	INTERMEDIATE GROOVE
4.0, 4.5, 4.75	3	1
4.5 – 2 RING	4	NONE
5.4 – 5M5515 PISTON AS.	4	1
5.4 – 1P435 AND 7N736 PISTON AS.	5	1
5.4 – OTHER	2	1
5.75	6	1 OR 5
6.25	4	1

DO NOT USE PISTON AGAIN IF GAUGE ENTERS RING GROOVE PAST LINE ON GAUGE

C39660P1 SEES5544

Piston Ring Groove Gauge Chart

Connecting Rod And Main Bearings

Bearings are available with a 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).

Flywheel And Flywheel Housing

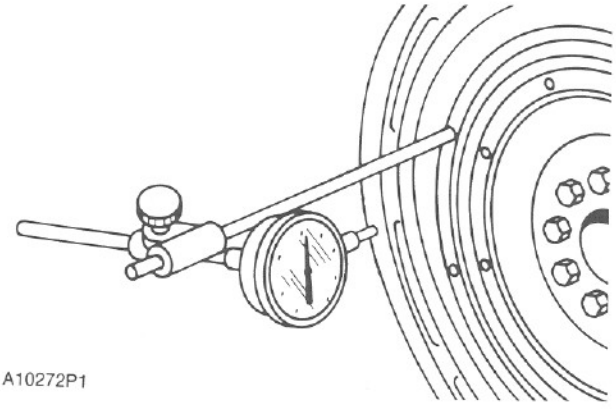
Tools Needed		
8T5096	Dial Indicator Group	1

Heat the ring gear to install it. Do not heat to more than 204°C (400°F). Install the ring gear so the chamfer on the gear teeth is next to the starter pinion when the flywheel is installed.

Face Runout (axial eccentricity) of the Flywheel Housing

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

1. Fasten a dial indicator to the crankshaft flange so the anvil of the indicator will touch the face of the flywheel housing.
2. Force the crankshaft to the rear before reading the indicator at each point.
3. With the dial indicator set at 0.0 mm (.00 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 0.25 mm (.010 in), which is the maximum permissible face runout (axial eccentricity) of the flywheel housing.



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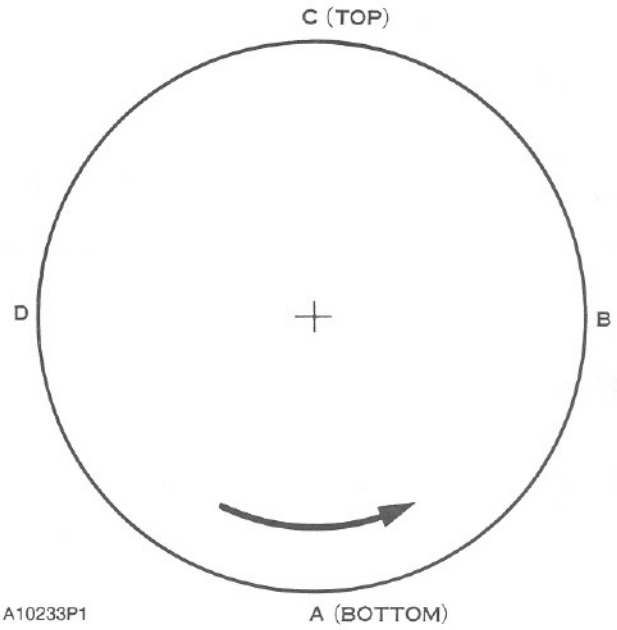
8T5096 Dial Indicator Group

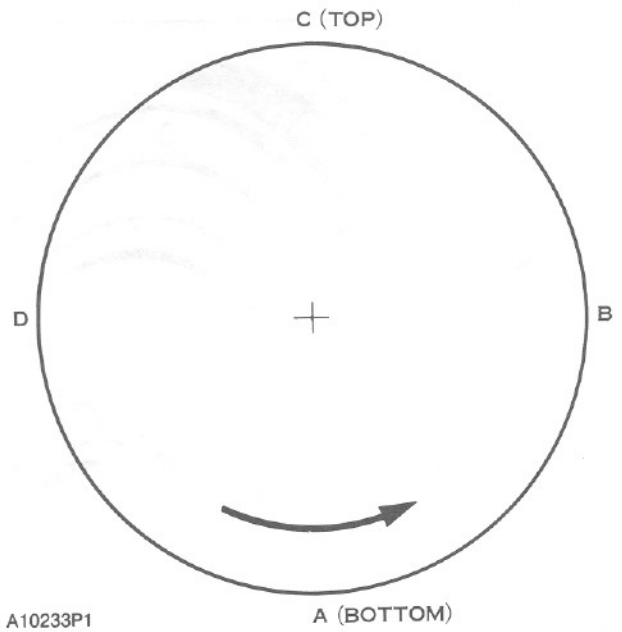


A10233P1

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

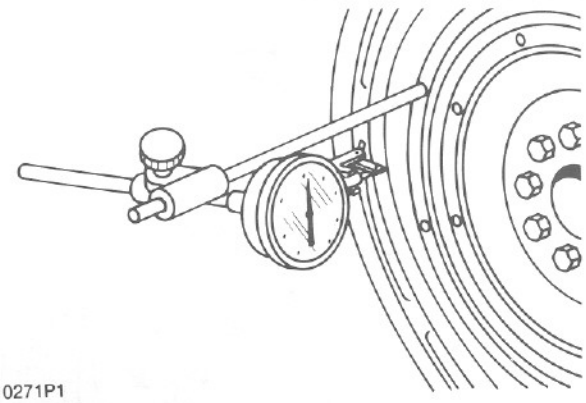
Bore Runout (Radial Eccentricity) Of The Flywheel Housing

1. With the dial indicator in position at (C), adjust the dial indicator to 0.0 mm (.00 in). Push the crankshaft up against the top bearing. Write the measurement for bearing clearance on line 1 in column (C).
2. Divide the measurement from Step 1 by 2. Write this number on line 1 in columns (B) & (D).



A10233P1

Checking Bore Runout Of The Flywheel Housing



A10271P1

8T5096 Dial Indicator Group Installed

3. Turn the crankshaft to put the dial indicator at (A). Adjust the dial indicator to 0.0 mm (.00 in).
4. Turn the crankshaft counterclockwise to put the dial indicator at (B). Write down the measurement in the chart.

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

5. Turn the crankshaft counterclockwise to put the dial indicator at (C). Write the measurement in the chart.
6. Turn the crankshaft counterclockwise to put the dial indicator at (D). Write the measurement in the chart.
7. Add lines I & II by columns.
8. 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 II, column (C) is the vertical eccentricity.

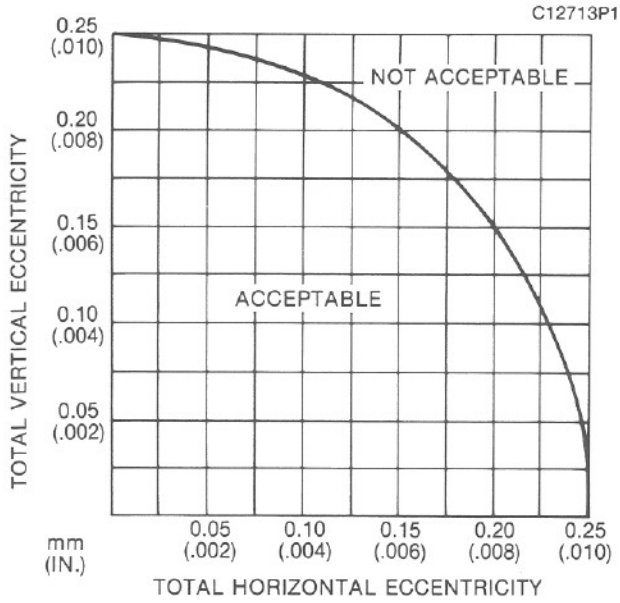
CHART FOR DIAL INDICATOR MEASUREMENTS

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

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

A10234P1

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

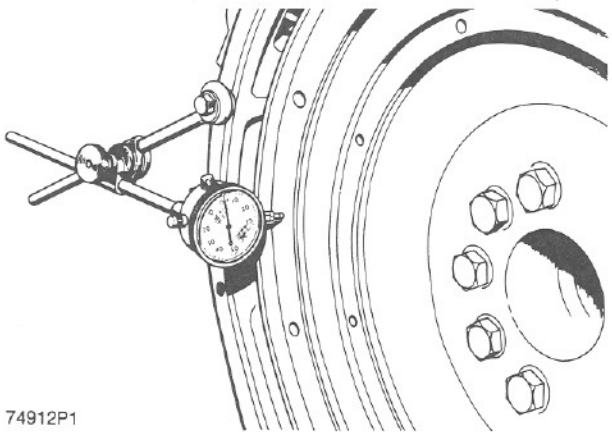


10. If the point of intersection is in the range marked "Acceptable" the bore is in alignment. If the point of intersection is in the range marked "Not Acceptable" the flywheel housing must be changed.

Face Runout (Axial Eccentricity) Of The Flywheel

1. Install the dial indicator as shown. Force the crankshaft the same way before the indicator is read so the crankshaft end clearance (movement) is always removed.

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



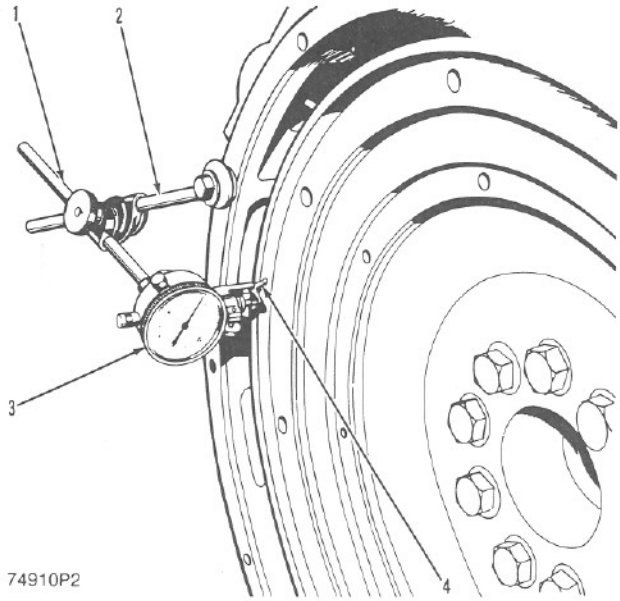
Checking Face Runout Of The Flywheel

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

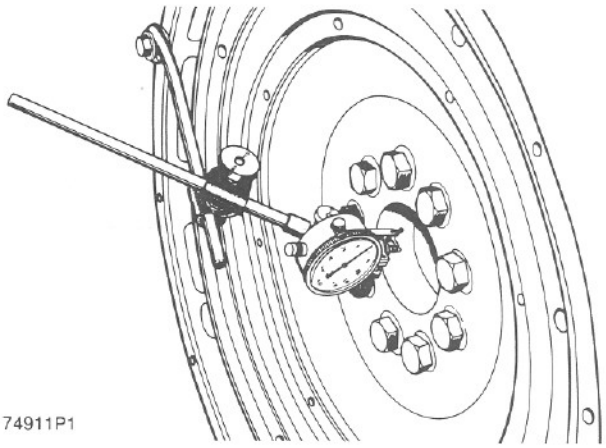
4. The difference between the lower and higher measurements taken at all four points must not be more than 0.15 mm (.006 in), which is the maximum permissible face runout (axial eccentricity) of the flywheel.

Bore Runout (Radial Eccentricity) Of The Flywheel

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



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



Checking Flywheel Clutch Pilot Bearing Bore

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

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

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 bore runout (radial eccentricity) of the flywheel.

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

Electrical System

Test Tools For Electrical System

Tools Needed		
6V4930	Battery Load Tester	1
8T0900	AC/DC Clamp-On Ammeter	1
6V7070	Heavy-Duty Digital Multimeter or	1
6V7800	Regular-Duty Digital Multimeter	1

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

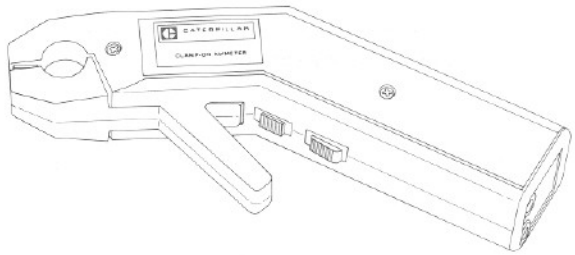
The service manual Testing And Adjusting Electrical Components, Form No. REG00636 has complete specifications and procedures for the components of the starting circuit and the charging circuit.

C31887P1

6V4930 Battery Load Tester

The 6V4930 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, and a load adjustment knob on the front panel permits a current range up to a maximum of 700 amperes. The tester also has a thermometer to show when the safe operating temperature limit of the unit has been reached.

NOTE: Make reference to Special Instruction, Form No. SEHS8268 for complete information for use of the 6V4930 Battery Load Tester.



C31895P1

8T0900 AC/DC Clamp-On Ammeter

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

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

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

6V7070 Heavy-Duty Digital Multimeter

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

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

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

Battery

⚠ WARNING

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

The battery circuit is an electrical load on the charging unit. The load is variable because of the condition of the charge in the battery. Damage to the charging unit 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.

Load test a battery that does not hold a charge when in use. To do this, put a resistance across the main connections (terminals) of the battery. For a 6, 8 or 12V battery, use a test load of three times the ampere/hour rating (the maximum test load on any battery is 500 amperes). Let the test load remove the charge (discharge) of the battery for 15 seconds and with the test load still applied, test the battery voltage. A 6V battery in good condition will show 4.5V; and 8V battery will show 6V; a 12V battery will show 9V. Each cell of a battery in good condition must show 1.6V on either a 6, 8 to 12V battery.

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 50 service hours).

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

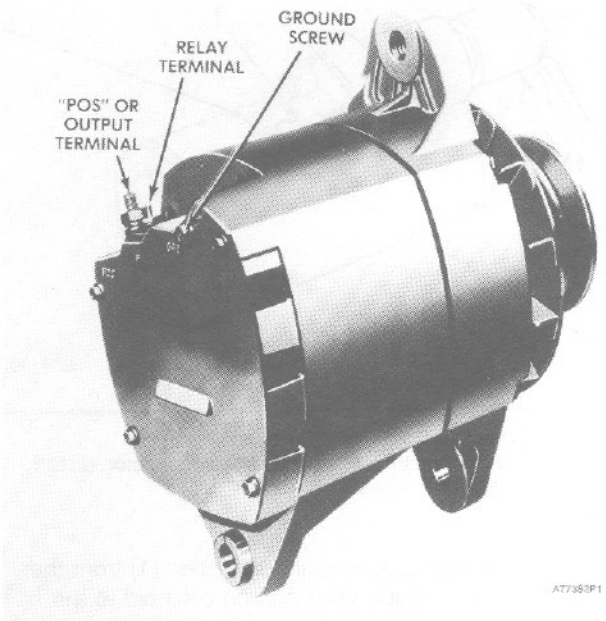
Before the start of on-engine testing, the charging system and battery must be checked as shown in the steps that follow:

1. Battery must be at least 75% (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

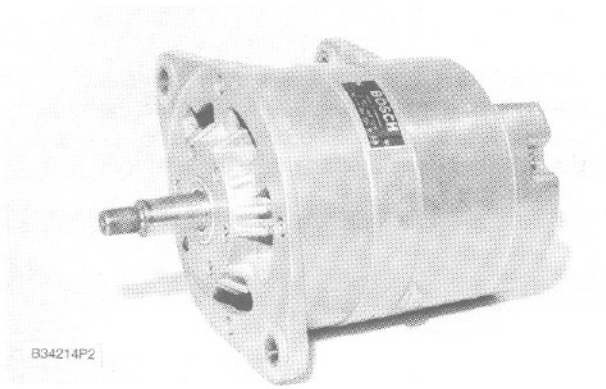
Delco-Remy

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



3T6352 Alternator Shown

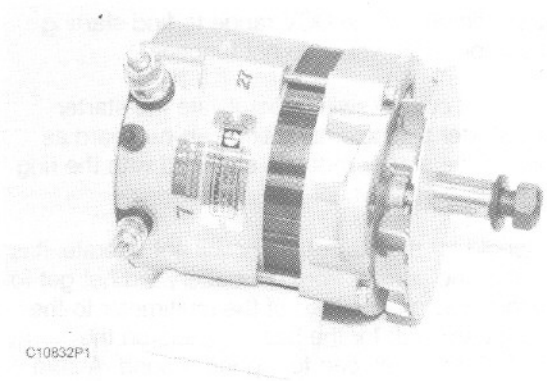
Bosch



7N9720 Alternator Shown

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

Nippondenso

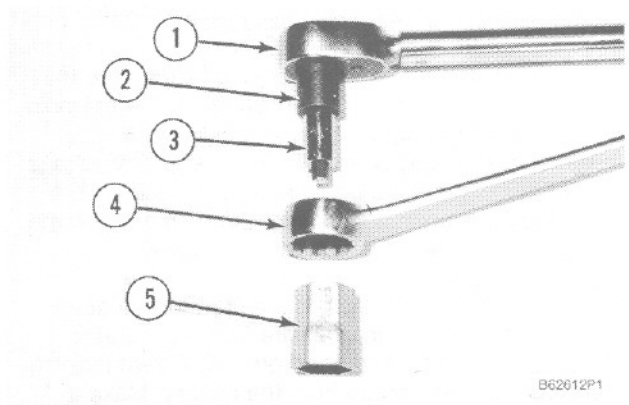


9G4574 Alternator Shown

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

Delco-Remy Alternator; Pulley Nut Tightening

Tighten nut that holds the pulley to a torque of 100 ± 7 N•m (75 ± 5 lb ft) with the tools shown.



Tools To Tighten Alternator Pulley Nut
(1) 6V7916 Torque Wrench. (2) 8S1588 Adapter (½" female to ⅜" male). (3) FT1697 Socket. (4) 8H8517 Combination Wrench (1 ⅛"). (5) FT1696 Wrench.

Starting System

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

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

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

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

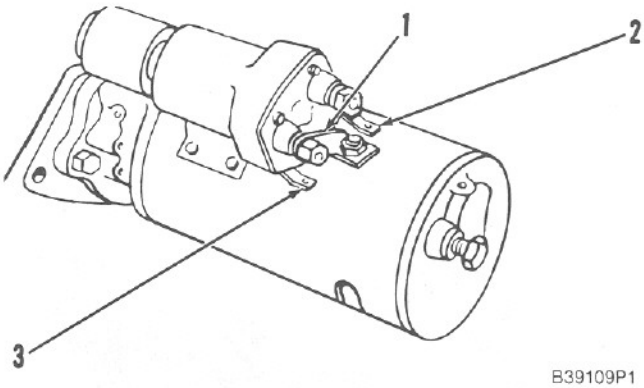
Make a test with one multimeter lead fastened to the connection (terminal) for the small wire at the solenoid and the other lead to the ground. Look at the multimeter and activate the starter solenoid. A voltage reading shows that the problem is in the solenoid. A zero reading is an indication that the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

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

A starter motor that operates too slow can have an overload because of too much friction in the engine being started. Slow operation of the starter motor can also be caused by a short circuit, loose connections and/or dirt in the motor.

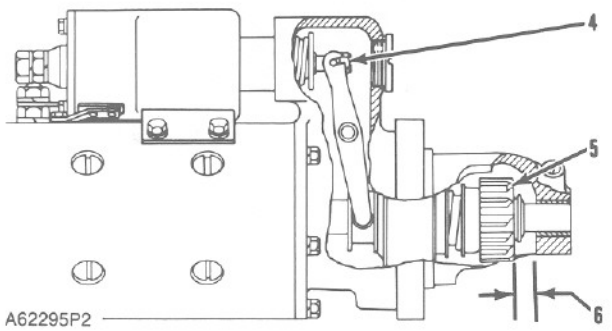
Pinion Clearance Adjustment (Delco-Remy)

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



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

1. Install the solenoid without connection (1) from the MOTOR connection (terminal) on solenoid to the motor.
2. Connect a battery, of the same voltage as the solenoid, to the terminal (2), marked SW.
3. Connect the other side of battery to ground terminal (3).
4. Connect for a moment, a wire from the solenoid connection (terminal) marked MOTOR to the ground connection (terminal). The pinion will shift to crank position and will stay there until the battery is disconnected.



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

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

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

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

Pinion Clearance Adjustment (Prestolite)

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

End Play For The Armature

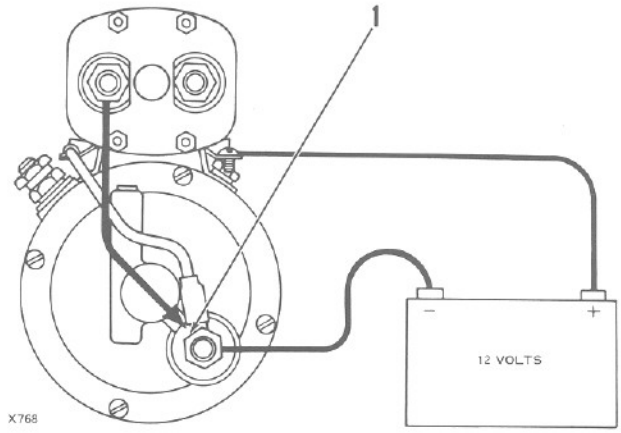
The correct end play for the armature is 0.13 to 0.76 mm (.005 to .030 in). The adjustment is made by adding or removing thrust washers on the commutator end of the armature shaft.

Pinion Clearance Adjustment

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

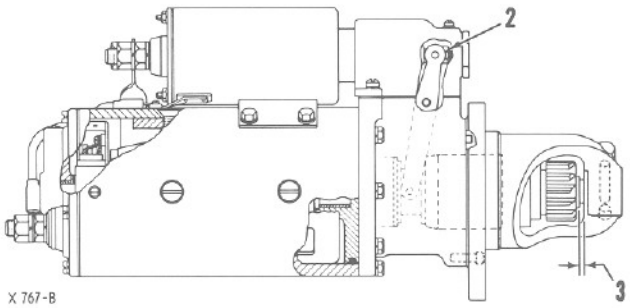
Disconnect the wire.

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



Connections For Adjustment Of The Pinion Clearance
(1) Stud

2. Push the drive toward the commutator end of the motor to eliminate any slack movement in the linkage and measure the distance between the outside edge of the drive sleeve and the thrust washer. The distance (3) must be 0.51 to 1.27 mm (.020 to .050 in).



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

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

4. Install the plug.