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Troubleshooting Guide (Section 4)

Troubleshooting

Introduction to the Troubleshooting Guide

This troubleshooting guide, when followed exactly as shown, can be an aid for the serviceman to find the cause of existing problems. The information from the measurements will also show proof if there is any basis for the complaint.

Be sure to get a good description of the problem from the operator and/or the person who owns the vehicle. What they tell you about the problem can save you time and make the repair job faster and easier.

Low Power and High Fuel Consumption Problems

The troubleshooting charts that follow provide a definite sequence to be followed for a logical, one by one elimination of many variables. The encircled numbers do not designate steps, but are references to detailed instructions that can not be shown on the chart. Always read the written material that corresponds with the encircled numbers on the charts.

The Primary Engine Tests consist of quick and easy procedures that could identify the problem with a minimum loss of time. Always make these tests before starting the more involved troubleshooting charts.

The necessary instruments to check each problem in sequence are shown on the chart. If the correct instrument is not available for the test, do not continue. The vehicle must be sent to a shop where the necessary tools are available.

Whenever a problem is found and corrected, always run the test again to that point to be sure there is not a combination of problems. When the problem has been corrected and the complaint resolved, stop the test. Do not continue through the complete procedure just because it is there.

When investigating possible causes, follow the letter sequence shown. Possible causes are arranged in order from more probable/easiest to check to less probable/more complex to check.

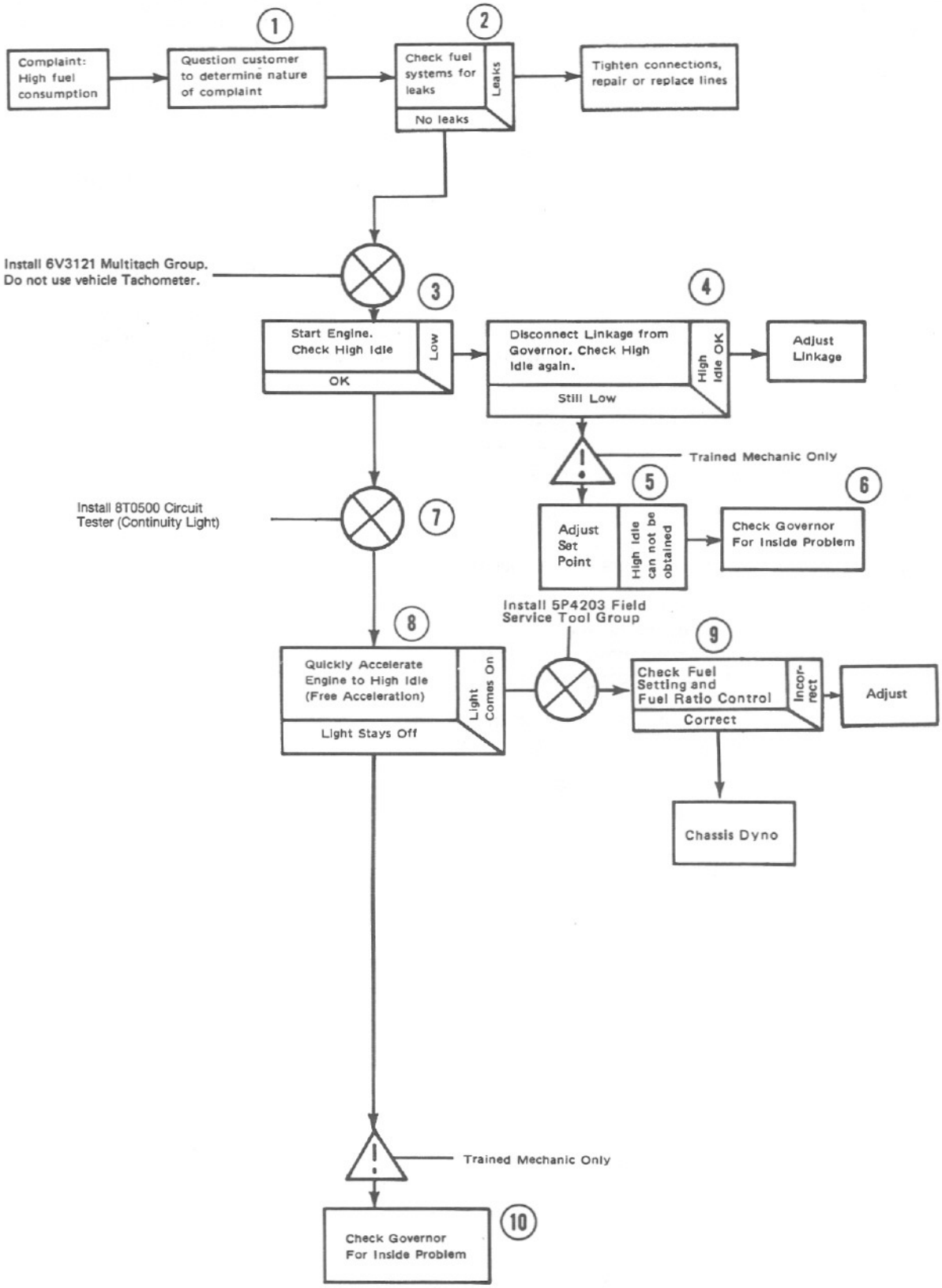
Other Problems: Vehicle Or Vehicle Operation, Misfiring And Running Rough, Too Much Exhaust Smoke, Difficult Starting, Cooling System, Loss Of Coolant, Or Fuel In Crankcase Oil.

The probable causes of a problem are given in the order they most commonly take place. Check the probable causes in the same order that they are given. When troubleshooting, use the section on recommended procedures which follow each chart to check and make the necessary corrections for each probable cause.

Engine Vibration Problem

The troubleshooting chart provides a definite sequence to be followed for a logical procedure to determine the frequency and amplitude of vibration so that the source of the vibration can be located and corrected.

PRIMARY ENGINE TEST
FOR HIGH FUEL CONSUMPTION



Primary Engine Test for Low Power

1. The customer must be asked many questions to determine whether his complaint is valid, or whether his diagnosis of an actual problem is correct.

Some of the questions that must be asked are as follows:

a. Does poor performance occur when the vehicle is operated at steady speed on a level road surface, or when vehicle is pulled up a grade?

A positive response to either or both of the above conditions would indicate a low power (steady state) problem. Begin with Low Power Diagnosis.

b. Does the poor performance always occur under the same conditions or is the problem intermittent (happens only occasionally)?

This is a very important line of questioning to pursue. Any constant performance problem can normally be identified and the problem corrected. If an intermittent problem exists, the mechanic must be aware that the condition is only occasional, and must run certain tests several times in an attempt to force the malfunction condition. If the condition is not duplicated, the diagnosis that no problem exists will be incorrect, and the vehicle operator will again be confronted with the problem somewhere out on the road.

c. Was the engine running rough or misfiring when the poor performance was noticed?

A positive response to this questions will indicate the need to isolate the bad cylinder(s) and correct the problem. See section Cylinder Misfire.

2. Check the crankcase oil level and the coolant level of the radiator. Start the engine and get to normal operating temperature. A slightly lower rpm (15 rpm below low limit) should be expected for the engine in vehicle than the rpm shown in the Fuel Setting And Related Information Fiche. This is caused by the parasitic loads of the engine accessories involved.

3. With the engine running, the throttle must have enough travel for the governor control lever to break over (go past the normal governor stop for high idle position) a small amount when the throttle pedal is fully depressed. If full travel is not available, disconnect throttle linkage from governor lever. With throttle linkage disconnected, full travel of governor lever will indicate linkage problems, and the linkage will have to be adjusted. Limited travel of the governor lever will indicate a problem within the governor.

4. Only a mechanic with the correct training should change the set point (balance point). The procedure is given in the Service Manual under the subject Governor Adjustments.

5. If the set point (balance point) cannot be made correct with the high idle adjustment screw, there is a problem inside the governor. Disassemble the governor and check for damaged parts or wrong parts installed in the governor. Some common problems are worn bushings, worn spring seat, or a broken or wrong governor spring.

6. Before 8T0500 Circuit Tester is installed, be sure to test the light for correct operation. Test light must come on when the clip of the wire is placed against the probe of the light (replace batteries or bulb if light does not come on).

NOTE: If light comes on and stays on when attached to governor, then insulation is bad or installed wrong in torque spring group or brass terminal. This must be corrected before test is performed.

7. With the continuity light installed, quickly push accelerator pedal all the way to the floor. If the fuel control shaft and governor functions properly, the continuity light will come on during this free acceleration until high idle is maintained.

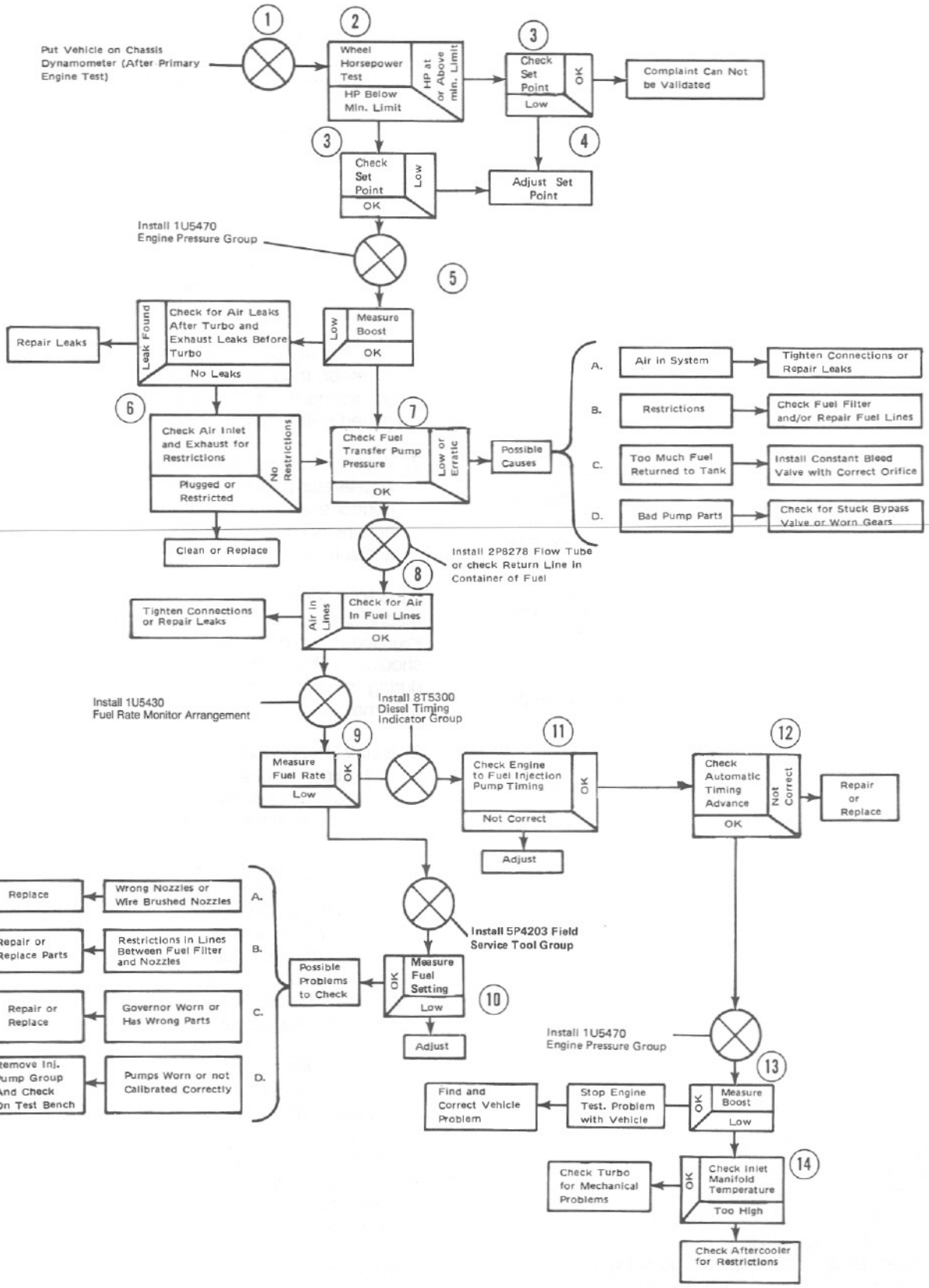
If the light comes on, this is an indication that the mechanical movement of the governor and fuel injection pump parts operate properly. The fuel setting should now be checked. If the light does not come on during free acceleration, check for a problem inside the governor.

8. Install 5P4203 Field Service Tool Group. Check the fuel ratio control and the fuel setting dimensions. Compare the results with the dimensions given in the Fuel Setting and Related Information Fiche.

If the fuel ratio control or the fuel settings are not correct, they must be adjusted to the settings given in the Fuel Setting and Related Information Fiche. Only a mechanic with the correct training should adjust the fuel ratio control and fuel settings. The procedure to check and adjust the fuel ratio control and the fuel setting is in this Service Manual under the subject Fuel Ratio Control Adjustment and Fuel Setting.

9. If the test light still does not come on, this means that the fuel control shaft is not moving due to a problem inside the governor or a problem inside fuel injection pump housing. The governor should be checked for worn parts. The fuel injection pump housing should be checked for a worn fuel control shaft or its bore, or a fuel injection pump installed with sleeve not engaged with the lever on the fuel control shaft. The problem must be found and corrected.

LOW POWER TROUBLESHOOTING
(Diagnosis with Chassis Dynamometer)



Low Power Troubleshooting

(Diagnosing with Chassis Dynamometer)

1. Preparation of vehicle for wheel horsepower test (consult dynamometer manufacturer's operating instructions for specific details on correct operation).

NOTE: Always perform the Primary Engine Test procedure before vehicle is installed on chassis dynamometer.

Calculate the allowable limits that the customer can expect from his engine and present these figures to him.

Caterpillar engines are rated with the conditions that follow:

Barometric pressure = 747 mm (29.4 in) of mercury
Inlet air temperature = 29°C (85°F) at air cleaner inlet
Fuel gravity = API gravity of 35 at 16°C (60°F)

Measure and record these variables.

a. Place vehicle on the chassis dynamometer. Tie the vehicle in a way that will not add any load to the drive wheels. Do not pull wheels down into dynamometer drive rolls.

Check the radiator coolant level, crankcase oil level, tire pressure, tire condition, remove rocks from the tire tread and connect exhaust system.

NOTICE

Recapped tires should be run on a chassis dynamometer only at the customer's own risk.

b. Operate vehicle at 60% of rated speed with moderate load until oil and coolant temperatures reach their normal range for operation.

NOTICE

If there is a heavy vibration, drive shaft whip, tire bounce, etc., do not continue with dynamometer test until cause of the problem is corrected. Engines that have had new internal parts installed should be operated on a run-in schedule before operation at full load. For run-in schedule information, make reference to General Instructions section of this Service Manual.

2. Put transmission in direct gear and the differential in the highest speed ratio. Operate vehicle at maximum engine speed and increase chassis dynamometer load until a speed of 50 rpm less than rated speed is reached (continuity light should be on). Maintain this speed for one minute and record the engine speed and wheel horsepower.

NOTE: If horsepower is low and poor maintenance is suspected, remove air cleaner and check horsepower again to see if a plugged air cleaner could be the problem.

3a. If the wheel horsepower is correct, find the set point (balance point) of the engine (speed at which the load stop pin just touches the torque spring or stop bar). At this point the continuity light should flicker (go off and on dimly).

If the set point (balance point) is correct, then the low power complaint cannot be validated. No further test or repairs are necessary.

If the set point (balance point) is low, see Procedure No. 4.

3b. If the wheel horsepower is below the correct value, find the set point (balance point) of the engine (speed at which the load stop pin just touches the torque spring or stop bar). At this point the continuity light should flicker (go off and on dimly).

If the set point (balance point) is correct, see Procedure No. 5.

If the set point (balance point) is low, see Procedure No. 4.

4. If the set point (balance point) is low, the high idle will have to be increased to raise the set point (balance point) to the correct rpm (the point at which the continuity light just comes on).

NOTE: If the set point (balance point) is still low and high idle has been adjusted to maximum, disengage clutch while maximum throttle position is maintained. Now observe high idle rpm and, if lower than previously adjusted, check frame-to-engine-mount. A damaged or loose engine mount may put the linkage in a bind and prevent maximum governor position at load conditions.

5. If the set point (balance point) was correct and the wheel horsepower was low, install the 1U5470 Engine Pressure Group and do the wheel horsepower test again as shown in Procedure No 2.

At full load rpm, measure the boost and the fuel pressure. See Fuel Setting and Related Information Fiche to find the correct boost pressure for a particular engine (since the engine is in vehicle, be sure to make reference to the General Notes in the Fuel Setting and Related Information Fiche to determine the correct boost pressure with air cleaner and muffler installed). If boost is low, check connections ahead of turbine side of turbocharger for exhaust leaks and connections after compressor side of turbocharger for inlet air leaks.

6. Check the air inlet restriction and exhaust back pressure.

Air flow through the air cleaner and piping must not have a vacuum restriction (negative pressure difference between atmospheric air and air that has gone through air cleaner) of more than 635 mm (25 in) of water. Back pressure from the exhaust (pressure difference measurement between exhaust outlet elbow and atmospheric air) must not be more than 1016 mm (40 in) of water.

Make a visual inspection of the air inlet system and check for damage to piping, rags or obstructions in the inlet piping, or damage to the rain cap or the cap pushed too far on the inlet pipe. If no damage is found, check inlet restriction with a new air cleaner element.

If there is too much exhaust restriction, make a visual inspection of the exhaust piping and muffler. If no visual damage can be found, the exhaust piping may have to be removed and the exhaust restriction measured again to see if problem is corrected.

7. The fuel transfer pump pressure (measured at plug on top of fuel pump housing) must not be less than 140 kPa (20 psi) at full load conditions. Normal fuel pressure at full load rpm is 205 ± 35 kPa (30 ± 5 psi). If fuel pressure is low or erratic, check for the conditions that follow in the order shown:

A. Air in the Fuel System . . . Disconnect the fuel return line at the tank. Place this end of the line in a container of fuel to see if air bubbles are present with the engine running. If air bubbles are observed, check for loose connections or other line leaks ahead of fuel transfer pump.

B. Restrictions . . . Check for a plugged fuel filter or crimped (damaged) fuel lines.

C. Too Much Fuel Returned to Tank . . . Block the fuel return line to stop all fuel returned to tank. Check fuel pressure again, and, if a significant pressure increase is observed, an incorrect constant bleed orifice may be the problem. Install the correct orifice.

NOTICE

Do not run the engine under load for more than 5 minutes with return line blocked.

D. Damaged Fuel Transfer Pump Parts . . . Check bypass valve to see if dirt or other debris could make the valve stick. Clean or replace valve if damaged. If bypass valve is good, remove and disassemble fuel transfer pump to check for wear in the gears.

8. A very small amount of air in the fuel may not affect the transfer pump fuel pressure, but could affect the performance at the nozzles. The 2P8278 Flow Tube can be installed ahead of the fuel transfer pump. This will allow a visual check of any air in the fuel when the engine is running. Another method to check for air in the fuel is to put the fuel tank end of the fuel return line in a container of fuel.

9. Install the 6V7925 Fuel Rate Indicator according to Special Instruction, Form No. SEHS8346. The specified fuel rate at full load is given in the Fuel Setting And Related Information Fiche.

Do the wheel horsepower test again as shown in Procedure No. 2, but this time record the fuel rate and rpm.

NOTE: This fuel system has a constant flow of fuel that is returned to the fuel tank. This orifice must be blocked before accurate fuel rate readings can be taken. Do not run the engine under load for more than 5 minutes with return line blocked.

10. If the fuel rate was too low, install 5P4203 Field Service Tool Group and check the fuel system setting. The correct fuel system setting is given in Fuel Setting And Related Information Fiche. If fuel system setting is not correct, the adjustment procedure is shown in the Testing and Adjusting section of this Service Manual under the subject Fuel System Setting.

If the fuel rate was low, and the fuel system setting is correct, check the items that follow in the sequence shown:

A. Remove nozzles and check to see if they are the correct nozzles for your engine or if they have been wire brushed. Either condition will affect performance.

B. Check for any restrictions to fuel flow in lines between fuel filter and nozzles. Any sharp bend in the lines could cause a restriction of fuel delivery.

C. Check governor for worn parts. A worn bushing or worn spring seat can change governor operation. Also check to see if the correct governor spring is installed.

D. Check fuel injection pumps for wear and for the correct calibration. Put the fuel injection pump group on the fuel injection test bench. Perform a fuel delivery test to determine if the correct amount of fuel is delivered by each pump.

11. Use the 8T5300 Diesel Timing Indicator Group to check the timing of the fuel injection pump camshaft to the engine camshaft. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group.

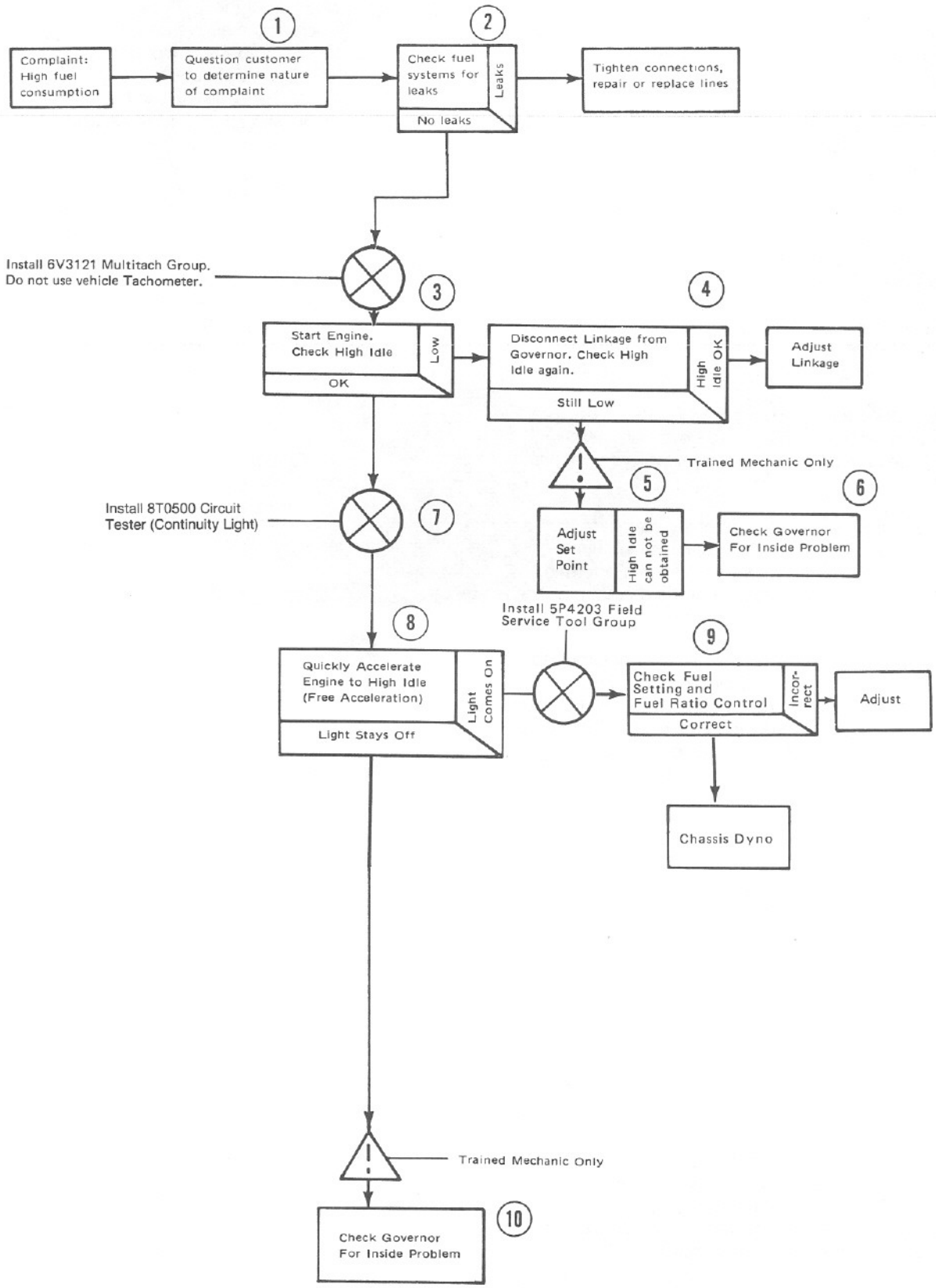
12. Use the 8T5300 Timing Indicator Group to check the automatic timing advance unit. Check to see that the advance is smooth and that the amount of advance is correct. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group.

If rpm, timing, and fuel rate are found to be within specifications, the engine should produce acceptable power (unless engine has excessive internal friction, ie, high crankcase oil level). When all the above conditions are within specifications, and the wheel horsepower is still lower than expected, some component of the vehicle must be absorbing too much power. Do not continue with engine troubleshooting, but locate and correct the problem with the vehicle. (Caterpillar is not responsible for problems with vehicle).

13. Measure the boost again as detailed in Procedure No. 5. If rpm, timing, fuel rate and boost are found to be within specifications, the engine should produce acceptable power (unless engine has excessive internal friction, i.e., high crankcase oil level). When all the above conditions are within specifications, and the wheel horsepower is still lower than expected, some component of the vehicle must be absorbing too much power. Do not continue with engine troubleshooting, but locate and correct the problem with the vehicle. (Caterpillar is not responsible for problems with vehicle).

14. If boost is still low, check inlet manifold temperature. If temperature is too high, check the aftercooler for possible restrictions to the coolant. This condition reduces the amount of air in cylinder for combustion (since warmer air is less dense). If manifold temperature is correct, check the turbocharger for mechanical problems (ie, wrong nozzles, worn bearings).

PRIMARY ENGINE TEST
FOR HIGH FUEL CONSUMPTION



Primary Engine Test for High Fuel Consumption

1. Fuel consumption records must be available before the high fuel consumption complaint can be verified. If symptoms indicate low power, then the low power test should be conducted first, because it could be the cause of the fuel consumption problem. This Primary Engine Test for High Fuel Consumption is the same as the Primary Engine Test for Low Power.

2. Visually inspect the fuel system from the fuel tank to the fuel injection lines to see if there are any indications of fuel leaks. Tighten any loose connections found and, if necessary, replace lines that can not be repaired.

3. Check the crankcase oil level and the coolant level of the radiator. Start the engine and get to normal operating temperature. A slightly lower rpm (15 rpm below low limit) should be expected for the engine in vehicle than the rpm shown in the Fuel Setting And Related Information Fiche. This is caused by the parasitic loads of the engine accessories involved.

4. With the engine running, the throttle must have enough travel for the governor control lever to break over (go past the normal governor stop for high idle position) a small amount when the throttle pedal is fully depressed. If full travel is not available, disconnect throttle linkage from governor lever. With throttle linkage disconnected, full travel of governor lever will indicate linkage problems, and the linkage will have to be adjusted. Limited travel of the governor lever will indicate a problem within the governor.

5. Only a mechanic with the correct training should change the set point (balance point) adjustment. The procedure is given in this Service Manual under the subject Governor Adjustments.

6. If high idle rpm can not be made correct with the high idle adjustment screw, there is a problem inside the governor. Disassemble the governor and check for damaged parts or wrong parts installed in the governor. Some common problems are worn bushings, worn spring seat, or a broken or wrong governor spring.

7. Before 8T0500 Circuit Tester is installed, be sure to test the light for correct operation. Test light must come on when the clip of the wire is placed against the probe of the light (replace batteries or bulb if light does not come on).

NOTE: If light comes on and stays on when attached to governor, the insulation is bad or installed wrong in torque spring group or brass terminal. This must be corrected before test is performed.

8. With the continuity light installed, quickly push accelerator pedal all the way to the floor. If the fuel control shaft and governor function properly, the continuity light will come on during this free acceleration until high idle is maintained.

If the light comes on, this is an indication that the mechanical movement of the governor and fuel injection pump parts operate properly. The fuel setting should now be checked. If the light does not come on during free acceleration, check for a problem inside the governor.

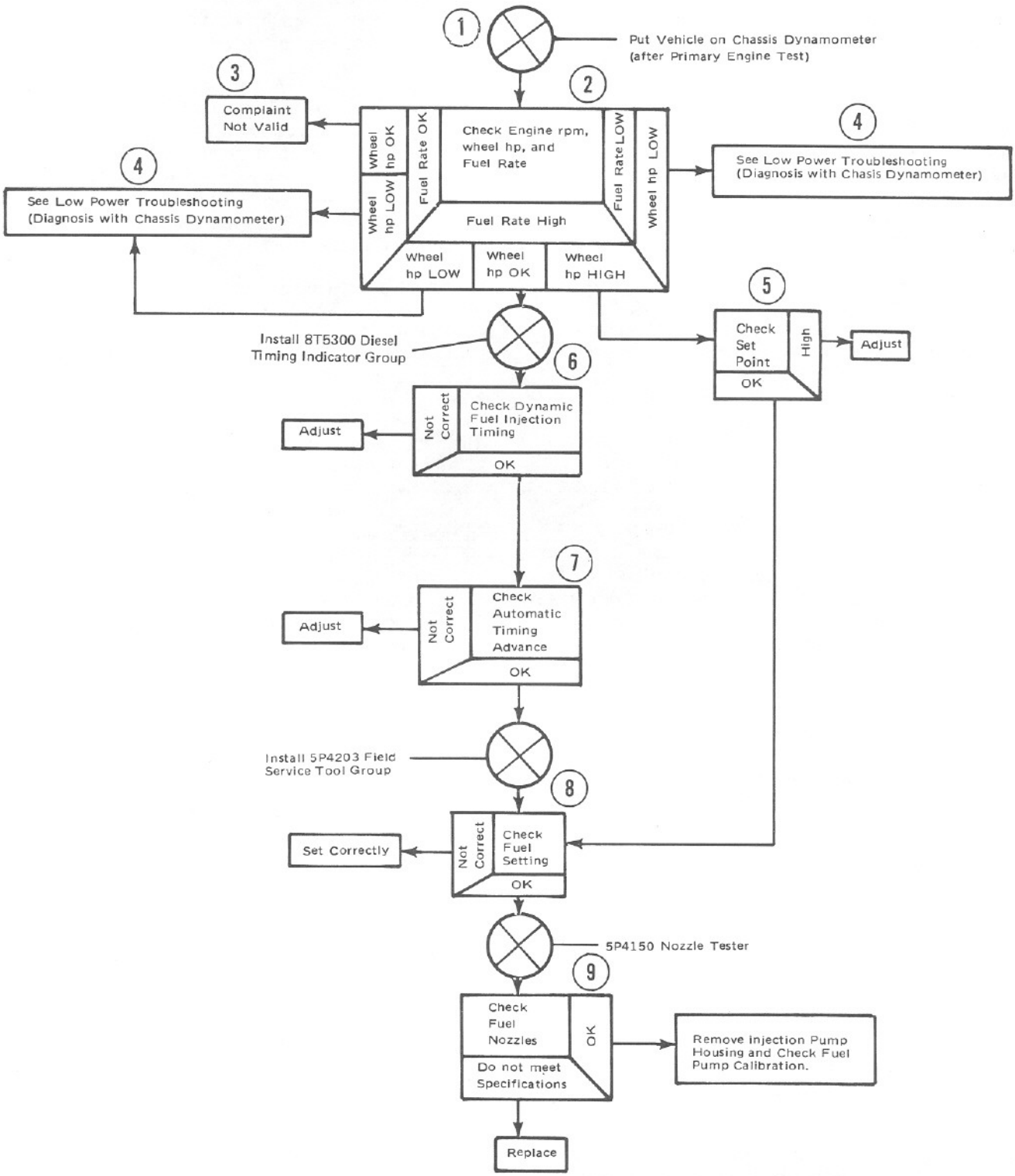
9. Install 5P4203 Field Service Tool Group, and check the fuel setting dimension. Compare the results with the dimensions given in the Fuel Setting and Related Information Fiche. If the fuel setting is correct, the vehicle will now have to be tested on a chassis dynamometer to determine the cause for high fuel consumption.

If the fuel setting is not correct, adjust to the setting given in the Fuel Setting and Related Information Fiche. Only a mechanic with the correct training should adjust the fuel setting. The procedure to check and adjust the fuel setting is in this Service Manual under the subject Fuel Setting.

10. If the test light still does not come on, this means that the fuel control shaft is not moving due to a problem inside the governor or a problem inside fuel injection pump housing. The governor should be checked for worn parts. The fuel injection pump housing should be checked for a worn fuel control shaft or its bore, or a fuel injection pump installed with sleeve not engaged with the lever on the fuel control shaft. The problem must be found and corrected.

HIGH FUEL CONSUMPTION

(Diagnosis with Chassis Dynamometer)



High Fuel Consumption Troubleshooting

(Diagnosis with Chassis Dynamometer)

1. Preparation of vehicle for fuel consumption test (consult dynamometer manufacturer's operating instructions for specific details on correct operation).

NOTE: Always perform the Primary Engine Test procedure before vehicle is installed on chassis dynamometer.

a. Place vehicle on the chassis dynamometer. Tie the vehicle in a way that will not add any load to the drive wheels. Do not pull wheels down into dynamometer drive rolls.

Check the radiator coolant level, crankcase oil level, tire pressure, tire condition, remove rocks from the tire tread and connect exhaust system.

NOTICE

Recapped tires should be run on a chassis dynamometer only at the customer's own risk.

b. The maximum acceptable fuel rate must be calculated for the customer's engine by use of the formula that follows:

$$\frac{1.03 \text{ bhp (BSFC} \pm .010)}{\text{Fuel Density (lbs/gal)}} = \text{Max. Fuel Rate* (gal/hr)}$$

* At standard SAE test conditions

Find the rated brake specific fuel consumption (lb-bhp/hr) from the Fuel Setting And Related Information Fiche and add 0.25 mm (.010 in) manufacturing tolerance. Multiply this value by the advertised engine horsepower (plus 3% manufactures tolerance) and divide by the density of the fuel (lbs/gal).

c. Calculate the allowable limits that the customer can expect from his engine and present these figures to him. Caterpillar engines are rated with the conditions that follow:

Barometric pressure= 747 mm (29.4 in) of mercury
Inlet air temperature= 29°C (85°F) at air cleaner inlet
Fuel gravity= API gravity of 35 at 16°C (60°F)

Measure and record these variables.

2. Operate vehicle at 60% of rated speed with moderate load until oil and coolant temperatures reach their normal range for operation.

NOTICE

If there is a heavy vibration, drive shaft whip, tire bounce, etc., do not continue with dynamometer test until cause of the problem is corrected. Engines that have had new internal parts installed should be operated on a run-in schedule before operation at full load.

Put transmission in direct gear and the differential in the highest speed ratio. Operate vehicle at maximum engine speed and increase chassis dynamometer load until a speed of 50 rpm less than rated speed is reached (continuity light should be on). Maintain this speed for one minute and record the engine speed, wheel horsepower and fuel rate.

3. If the fuel rate and the wheel horsepower are both acceptable, then the engine is not the cause of the complaint, or the complaint is not valid. Refer to section Problem With Vehicle Or Vehicle Operation.

4. If the wheel horsepower is low, regardless of how the fuel rate measures, refer to the Low Power Troubleshooting Chart. The low power problem must be corrected first.

5. If the fuel rate and wheel horsepower are both too high, check the set point (balance point) of the engine (speed at which the load stop pin just touches the torque spring or stop bar). At this point the continuity light should flicker (go off and on dimly).

If the set point (balance point) is high, the high idle will have to be decreased to lower the set point (balance point) to the correct rpm (point at which the continuity light just comes on). If the set point (balance point) is correct, see Procedure No. 8.

6. If the fuel rate is high and the wheel horsepower is acceptable, use the 8T5300 Timing Indicator Group to check the timing of the fuel injection pump camshaft to the engine camshaft. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group. If the timing is correct, see Procedure No 7.

7. Use the 8T5300 Timing Indicator Group to check the automatic timing advance unit. Check to see that the advance is smooth and that the amount of advance is correct. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group.

8. If the fuel rate is still too high, install 5P4203 Field Service Tool Group and check the fuel setting. The correct fuel setting is given in Fuel Setting And Related Information Fiche. If fuel setting is not correct, the adjustment procedure is shown in Testing and Adjusting section of this Service Manual under subject Fuel Setting. If fuel setting is correct, see Procedure No 9.

9. Check the fuel nozzles with the 5P4150 Nozzle Tester. 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.

If the nozzles have been wire brushed or do not meet Caterpillar specifications, they must be replaced.

If the nozzles are good, remove the complete fuel injection pump housing and check the fuel pump calibration. See Fuel Pump Calibration in Testing and Adjusting section of this Service Manual.

Problem With Vehicle Or Vehicle Operation

PROBLEM WITH VEHICLE OR VEHICLE OPERATION

Probable Cause(s)

1. Tachometer Error
2. Engine Operated at High Altitude
3. Brakes Do Not Completely Release
4. Vehicle Operated in Too High a Gear
5. Extra Engine Driven Equipment
6. Speedometer Error
7. Speeds Too High
8. Overload on Vehicle
9. High Moving Resistance
10. High Wind Resistance
11. Power Loss in Drive Gears
12. Wrong Gear Ratios
13. Chassis Dynamometer Error
14. Trailers That are Difficult to Pull
15. High Inlet Air Temperature

The problems in this chart are problems that do come about and are normally called "low power." These problems are not necessarily more common than engine problems, but they are possible problems which you need to read and check before an engine is disassembled.

Read all of the items but make sure the first four are checked completely before making any engine test.

Problem With Vehicle Or Vehicle Operation

Recommended Procedure

1. Tachometer Error . . . To check, connect a tachometer of known accuracy to the engine. Run the engine and make a comparison of the readings of the vehicle and test tachometers. If vehicle tachometer is bad, make repairs as necessary or install a new tachometer.

2. Engine Operated at High Altitude . . . Less oxygen at higher altitudes causes the engine horsepower to go down. There is no effect on the 225 horsepower engine for the first 2280 m (7500 ft) above sea level of operation. There is no effect on the 235 and 250 horsepower engines for the first 1524 m (5000 ft) above sea level of operation. See the Fuel Setting And Related Information Fiche for the correct fuel setting for the higher altitude of operation.

3. Brakes Do Not Completely Release . . . Check the brakes by feeling all the brake drums. If the brakes of a wheel do not completely release, the brake drum for that wheel will be hotter than the brake drums for the other wheels. With the truck lifted with a jack, the wheels must have free rotation when turned by hand.

4. Vehicle Operated in Too High a Gear . . . If the operator does not shift the truck correctly, or operates the truck in a "lug" condition (using the truck in too high a gear for engine rpm to go up as accelerator pedal is pushed farther down, or using the truck in a gear where engine rpm goes down with accelerator pedal at maximum travel), poor vehicle performance is the result.

5. Extra Engine Driven Equipment . . . Air compressors, hydraulic pumps, alternators and other engine driven equipment that has damage, or that was not installed correctly, or that is not in correct adjustment can take more horsepower to drive than expected. If necessary, disconnect the equipment and test the engine.

6. Speedometer Error . . . A bad speedometer does not give the correct speed or the correct indication of fuel consumption. An indication of low speed can cause the operator to feel that he has a power problem.

7. Speeds Too High . . . The need for more horsepower is easy to see as the speed of the vehicle is increased. This is especially true if the front of the vehicle has a large surface area. Application personnel can give you the horsepower necessary for different vehicle designs at different speeds.

8. Overload on Vehicle . . . Application personnel can give you the horsepower needs for different vehicles.

9. High Moving Resistance . . . Soft ground conditions cause a need for more horsepower. To see if the problem is the engine, test the vehicle on a surface known to be good, or test on a chassis dynamometer.

10. High Wind Resistance . . . The horsepower needs for a truck can be divided into two parts. Part of the horsepower is used to move the vehicle and part is used to get through the resistance of the wind. The horsepower necessary to get through the resistance of the wind will increase as the vehicle is used at higher speeds. Vehicles with large front area have a higher wind resistance and take more horsepower than those with a small front area. Some types of trucks, for example, those used for the transportation of automobiles and/or boats have high wind resistance even if the front area is small. Moving against the wind has the same effect on wind resistance as does higher vehicle speed.

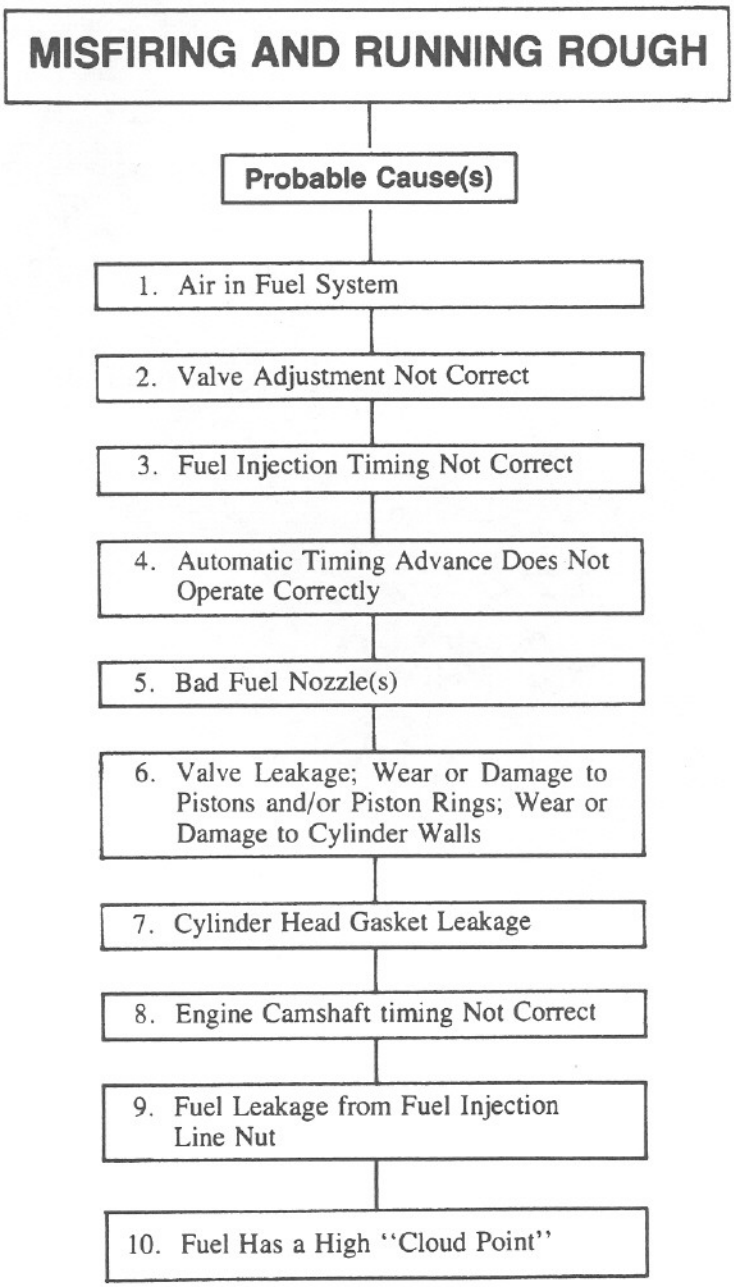
11. Power Loss in Drive Gears . . . It is possible for a transmission or rear axle to use extra horsepower because of damage, not being in correct adjustment, having the wrong type of fluid or not enough fluid in them, or an inside mechanical problem. If a part of the drive train unit operates at a higher temperature than normal, it can be the problem. Check this part of the drive train unit before working on any other part of the drive train unit. Powershift or automatic transmissions can cause the vehicle performance to be low if they are out of adjustment or not working correctly. See the transmission Service Manual for the correct adjustments.

12. Wrong Gear Ratios . . . The tire size, rear axle ratio, and transmission gear ratios must be correct to get maximum performance. If the transmission gear ratios are wrong, they can cause the engine rpm to go low enough during shifting that the engine can not have correct "acceleration" (increase in speed). A rear axle gear ratio which supplies too high a vehicle speed with the engine at a low rpm during normal vehicle operation, will cause the engine to be "lugging" (when the truck is used in a gear too high for engine rpm to go up as accelerator pedal is pushed farther down, or when the truck is used in a gear where engine rpm goes down with accelerator pedal at maximum travel). Application personnel can give you the correct tire sizes and gear ratios for your operation.

13. Chassis Dynamometer Error . . . Chassis dynamometers can be a great help in testing a vehicle for engine performance if they are in good condition and used correctly. When the dynamometer is not in good condition, or a bad operating procedure is used, the result will be wrong readings. For good comparison of horsepower readings from different vehicles, use the same dynamometer with the same operator.

14. Trailers That Are Difficult to Pull . . . Some trailers are more difficult to pull than others because of several factors. Some of these factors are: brakes not released completely, high wind resistance (because of a large front area and/or the design of the trailer), axles not in alignment, extra axles, and low tire pressure.

15. High Inlet Air Temperature . . . Air coming into the engine must be cool for the engine to have full horsepower. If the air inlet system is not of correct design or is not in good mechanical condition, hot air can come into the engine causing a loss of horsepower. To check the inlet air temperature, install the 8T0470 Thermistor Thermometer Group into the engine air inlet pipe.


MISFIRING AND RUNNING ROUGH
Probable Cause(s)
1. Air in Fuel System
2. Valve Adjustment Not Correct
3. Fuel Injection Timing Not Correct
4. Automatic Timing Advance Does Not Operate Correctly
5. Bad Fuel Nozzle(s)
6. Valve Leakage; Wear or Damage to Pistons and/or Piston Rings; Wear or Damage to Cylinder Walls
7. Cylinder Head Gasket Leakage
8. Engine Camshaft timing Not Correct
9. Fuel Leakage from Fuel Injection Line Nut
10. Fuel Has a High "Cloud Point"

Misfiring And Running Rough

Recommended Procedure

1. Air in Fuel System . . . With air in the fuel system the engine will normally be difficult to start, run rough and release a large amount of white smoke. To remove the air from the fuel system, open the manual bleed valve on the fuel injection pump housing. Operate the priming pump until the flow of fuel from the manual bleed valve is free of air. Close the manual bleed valve and fasten the fuel priming pump. Start the engine. If the engine still does not run smooth or releases a large amount of white smoke, loosen the fuel line nuts one at a time at the cylinder heads, and permit the fuel to come out until it is free of air. Tighten the fuel line nuts. If air is not removed in this way, put 35 kPa (5 psi) of air pressure to the fuel tank.

NOTICE

Do not use more than 55 kPa (8 psi) of air pressure in the fuel tank or damage to the tank may result.

Check for leaks at the connections between the fuel tank and the fuel transfer pump. If leaks are found, tighten the connections or replace the lines. If there are no visual leaks, remove the fuel supply line from the tank and connect it to an outside fuel supply. If this corrects the problem, the suction line (standpipe) inside the fuel tank has a leak.

2. Valve Adjustment Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting Section of this Service Manual. Intake valve clearance is 0.38 mm (.015 in) and exhaust valve clearance is 0.64 mm (.025 in). Also check for a bent or broken push rod.

3. Fuel Injection Timing Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting Section of this Service Manual.

4. Automatic Timing Advance Does Not Operate Correctly . . . Check with engine warm. Use the 8T5300 Timing Indicator Group to check the automatic timing advance unit. Check to see that the advance is smooth and that the amount of advance is correct. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group. If the timing indicator is not available, make rapid "acceleration" (increase in speed) from low idle to high idle. Engine must have smooth acceleration. A timing advance that does not operate correctly can cause delays of the engine acceleration at some rpm before high idle, or possibly cause the engine to run rough and have exhaust noise (backfire) during acceleration. This condition is difficult to find if engine acceleration is slow or at a constant engine rpm.

5. Bad Fuel Nozzle(s) . . . Find a bad nozzle by running engine at the rpm where it runs rough. Loosen the fuel line nut at the cylinder head enough to stop fuel supply to that cylinder. Each cylinder must be checked this way. If a cylinder is found where loosening of the nut makes no difference in the rough running, test the nozzle for that cylinder. To test a nozzle, remove the nozzle from the engine and test.

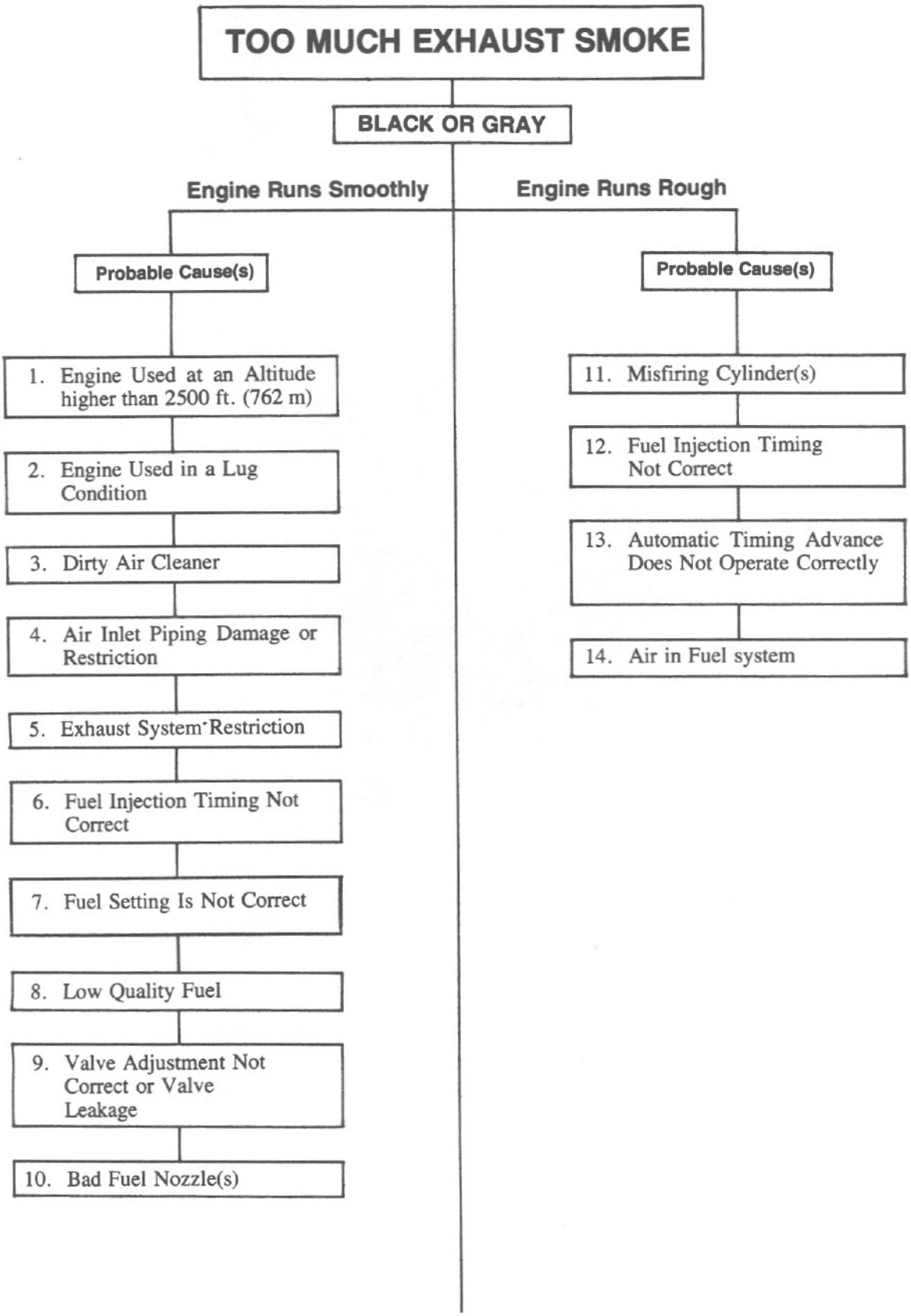
6. Valve Leakage; Wear or Damage to Pistons and/or Piston Rings; Wear or Damage to Cylinder Walls . . . The condition of these parts can be checked with a cylinder leakage tester. Special Instruction, Form No. GMG00694, gives the test procedure. The components can be bad if leakage is more than the specifications. If leakage is heard at the inlet manifold, the intake valves leak. If the leakage is heard at the exhaust manifold, the exhaust valves leak. If leakage is heard at the oil filler opening, the piston rings leak.

7. Cylinder Head Gasket Leakage . . . Check with the cylinder leakage tester. If leakage is higher than specifications, check at the fuel nozzle hole of the next cylinder to see if the leak is between cylinders. Leakage at the gasket of the cylinder head can show as an outside leak or can cause loss of coolant through the radiator overflow.

8. Engine Camshaft Timing Not Correct . . . Engine camshaft timing can be checked by finding the top center position for number one cylinder as per Testing and Adjusting section of this Service Manual. If timing is not correct remove the front cover and check timing marks. If timing marks are correct check for a broken drive dowel in the camshaft drive gear.

9. Fuel Leakage from Fuel Injection Line Nut . . . Tighten nut to 42 ± 7 N•m (31 ± 5 lb ft). Again check for leakage.

10. Fuel Has a High "Cloud Point" . . . The fuel "cloud point" is the temperature at which wax begins to form in the fuel. If the atmospheric temperature is lower than the "cloud point" of the fuel, wax will form and plug the filter. Change the filter and drain the tank and the complete fuel system. The replacement fuel must be of a better grade with a lower "cloud point".


TOO MUCH EXHAUST SMOKE
BLACK OR GRAY
Engine Runs Smoothly
Engine Runs Rough
Probable Cause(s)
Probable Cause(s)
1. Engine Used at an Altitude higher than 2500 ft. (762 m)
2. Engine Used in a Lug Condition
3. Dirty Air Cleaner
4. Air Inlet Piping Damage or Restriction
5. Exhaust System Restriction
6. Fuel Injection Timing Not Correct
7. Fuel Setting Is Not Correct
8. Low Quality Fuel
9. Valve Adjustment Not Correct or Valve Leakage
10. Bad Fuel Nozzle(s)
11. Misfiring Cylinder(s)
12. Fuel Injection Timing Not Correct
13. Automatic Timing Advance Does Not Operate Correctly
14. Air in Fuel system

Too Much Exhaust Smoke

Black or Gray

Engine Runs Smoothly

Recommended Procedure

1. Engine Used in a Lug Condition . . . "Lugging" (when the truck is used in a gear too high for engine rpm to go up as accelerator pedal is pushed farther down, or when the truck is used in a gear where engine rpm goes down with accelerator pedal at maximum travel) the engine causes a reduction in the intake of air with full fuel delivery to the cylinders. Because there is not enough air to burn all the fuel, the fuel that is not used comes out the exhaust as black smoke. To prevent lugging the engine, use a gear where engine can have "acceleration" (increase in speed) under load.

2. Dirty Air Cleaner . . . If the air cleaner has a restriction indicator, see if the red piston is in view. If there is no restriction indicator, restriction can be checked with a water manometer or a vacuum gauge (which measures in inches of water). Make a connection to the piping between the air cleaner and the inlet of the turbocharger. Check with the engine running at full load rpm. Maximum restriction is 635 mm (25 in) of water. If a gauge is not available, visually check the air cleaner element for dirt. If the element is dirty, clean the element or install a new element.

3. Air Inlet Piping Damage or Restriction . . . Make a visual inspection of the air inlet system and check for damage to piping, rags in the inlet piping, or damage to the rain cap or the cap pushed too far on the inlet pipe. If no damage is seen, check inlet restriction with a clean air cleaner element.

4. Exhaust System Restriction . . . Make a visual inspection of the exhaust system. Check for damage to piping or for a bad muffler. If no damage is found, you can check the system by checking the back pressure from the exhaust (pressure difference measurement between exhaust outlet and atmosphere). The back pressure must not be more than 1016 mm (40 in) of water. You can also check by removing the exhaust pipes from the exhaust manifolds. With the exhaust pipes removed, start and load the engine on a chassis dynamometer to see if the problem is corrected.

5. Fuel Injection Timing Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual.

6. Fuel Setting is Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting Section of this Service Manual. See the Fuel Setting And Related Information Fiche for the correct fuel setting.

7. Low Quality Fuel . . . Test the engine with fuel according to recommendations by Caterpillar.

8. Valve Adjustment Not Correct or Valve Leakage . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual. Intake valve clearance is 0.38 mm (.015 in) and exhaust valve clearance is 0.64 mm (0.25 in). Valve leakage normally causes the engine to "misfire" (injection not regular) and run rough. Valve leakage can be checked using the cylinder leakage tester. Special Instruction, Form No. GMG00694 gives the test procedure.

9. Bad Fuel Nozzles . . . Bad fuel nozzles will normally cause the engine to "misfire" (injection not regular) and run rough, but can cause too much smoke with engine still running smooth. Remove and test the fuel nozzles.

Engine Runs Rough

10. Misfiring Cylinder(s) . . . See Misfiring and Running Rough.

11. Fuel Injection Timing Not Correct. . .Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual.

12. Automatic Timing Advance Does Not Operate Correctly . . . Check with engine warm. Use the 8T5300 Timing Indicator Group to check the automatic timing advance unit. Check to see that the advance is smooth and that the amount of advance is correct. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group. If the timing indicator is not available, make rapid "acceleration" (increase in speed) from low idle to high idle. Engine must have smooth acceleration. A timing advance that does not operate correctly can cause delays of the engine acceleration at some rpm before high idle, or possibly cause the engine to run rough and have exhaust noise (backfire) during acceleration. This condition is difficult to find if engine acceleration is slow or at a constant engine rpm.

13. Air in Fuel System . . . With air in the fuel system the engine will normally be difficult to start, run rough and release a large amount of white smoke. To remove the air from the fuel system open the manual bleed valve on the fuel injection pump housing. Operate the priming pump until the flow of fuel from the manual bleed valve is free of air. Close the manual bleed valve and fasten the fuel priming pump. Start the engine. If the engine still does not run smooth or releases a large amount of white smoke, loosen the fuel line nuts one at a time at the cylinder heads, and permit the fuel to come out until it is free of air. Tighten the fuel line nuts. If air is not removed in this way, put 35 kPa (5 psi) of air pressure to the fuel tank.

NOTICE

Do not use more than 55 kPa (8 psi) of air pressure in the fuel tank or damage to the tank may result.

Check for leakage at the connections between the fuel tank and the fuel transfer pump. If leaks are found, tighten the connections or replace the lines. If there are no visual leaks, remove the fuel supply line from the tank and connect it to an outside fuel supply. If this corrects the problem, the suction line (standpipe) inside the fuel tank has a leak.

Too Much Exhaust Smoke

White Smoke
Blue Smoke

TOO MUCH EXHAUST SMOKE

Probable Cause(s)

White Smoke

1. Cold Outside Temperatures
2. Long Idle Periods
3. Low Quality Fuel
4. Air in Fuel System
5. Fuel Injection Timing Not Correct
6. Automatic Timing Advance Does Not Operate Correctly
7. Valve Adjustment Not Correct
8. Bad Fuel Nozzles(s)
9. Misfiring Cylinder(s)

Blue Smoke

10. Oil Level in Engine Too High
11. Damage to Positive Crankcase Ventilator Valve or Valve Assembled Wrong
12. Worn Valve Guides
13. Worn Piston Rings and/or Cylinder Walls
14. Wear or Damage to Pistons

Too Much Exhaust Smoke

White Smoke

Recommended Procedure

1. Cold Outside Temperatures . . . When the air outside is cold, the cylinder temperature is cooler. Not all the fuel will burn in the cylinders. The fuel which does not burn comes out the exhaust as white smoke. White smoke is normal in cold temperatures until the engine operates long enough to become warm. There will be less white smoke if No. 1 diesel fuel is used.

2. Long Idle Periods . . . When an engine runs at idle speed for a long period of time, the cylinders cool and all of the fuel does not burn. Do not idle an engine for a long period of time. Stop an engine when it is not in use. If long idle periods are necessary, use No. 1 diesel fuel.

3. Low Quality Fuel . . . Test the engine using fuel according to recommendations by Caterpillar.

4. Air in Fuel System . . . With air in the fuel system the engine will normally be difficult to start, run rough and release a large amount of white smoke. To remove the air from the fuel system open the manual bleed valve on the fuel injection pump housing. Operate the priming pump until the flow of fuel from the manual bleed valve is free of air. Close the manual bleed valve and fasten the fuel priming pump. Start the engine. If the engine still does not run smooth or releases a large amount of white smoke, loosen the fuel line nuts one at a time at the cylinder heads, and permit the fuel to come out until it is free of air. Tighten the fuel line nuts. If air is not removed in this way, put 35 kPa (5 psi) of air pressure to the fuel tank.

NOTICE

Do not use more than 55 kPa (8 psi) of air pressure in the fuel tank or damage to the tank may result.

Check for leakage at the connections between the fuel tank and the fuel transfer pump. If leaks are found, tighten the connections or replace the lines. If there are no visual leaks, remove the fuel supply line from the tank and connect it to an outside fuel supply. If this corrects the problem, the suction line (standpipe) inside the fuel tank has a leak.

5. Fuel Injection Timing Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual.

6. Automatic Timing Advance Does Not Operate Correctly . . . Check with engine warm. Use the 8T5300 Timing Indicator Group to check the automatic timing advance unit. Check to see that the advance is smooth and that the amount of advance is correct. See Fuel System of the Testing and Adjusting section of this Service Manual for the subject Checking Engine Timing And Automatic Timing Advance Unit With 8T5300 Timing Indicator Group. If the timing indicator is not available, make rapid "acceleration" (increase in speed) from low idle to high idle. Engine must have smooth acceleration. A timing advance that does not operate correctly can cause delays of the engine acceleration at some rpm before high idle, or possibly cause the engine to run rough and have exhaust noise (backfire) during acceleration. This condition is difficult to find if engine acceleration is slow or at a constant engine rpm.

7. Valve Adjustment Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual. Intake valve clearance is 0.38 mm (.015 in) and exhaust valve clearance is 0.64 mm (.025 in).

8. Bad Fuel Nozzles(s) . . . Bad Fuel nozzles will normally cause the engine to "misfire" (injection not regular) and run rough, but can cause too much smoke and the engine still be running smooth. Remove and test the fuel nozzles.

9. Misfiring Cylinder(s) . . . See Misfiring and Running Rough.

Blue Smoke

10. Engine Oil Level Too High . . . Do not put too much oil in the crankcase. If the oil level in the crankcase goes up as the engine is used, check for fuel in the crankcase. See Fuel In Crankcase Oil.

11. Damage to Positive Crankcase Ventilator Valve or Valve Assembled Wrong . . . The positive crankcase ventilator valve must be assembled correctly and the diaphragm and/or gasket must be free of damage.

12. Worn Valve Guides . . . See the Specifications section of this Service Manual for the maximum permissible wear of the valve guides. The repair procedure for valve guides is in the Reconditioning Procedures section of this Service Manual.

13. Worn Piston Rings and/or Cylinder Walls . . . Worn piston rings and/or cylinder walls can be the cause of blue smoke and can cause a loss of compression. Check cylinder condition with the cylinder leakage tester. Special Instruction, Form No. GMG00694, gives the test procedure. Make a visual inspection of the cylinder walls and piston rings. If necessary measure the cylinder walls and piston rings. For the cylinder and piston ring specifications see the Specification section of this Service Manual. NOTE: High wear at low mileage is normally caused by dirt coming into the engine with the inlet air.

14. Wear or Damage to Pistons . . . Check piston ring to groove clearance. Pistons which have worn grooves and pistons with damage or defects can cause blue smoke and too much oil consumption. Make sure the oil return holes under the oil ring are open.

Difficult Starting

Engine Crankshaft Turns Freely

DIFFICULT STARTING

Engine Crankshaft Turns Freely

Exhaust Smoke Can Be Seen While Starting

Probable Cause(s)

1. Cold Outside Temperatures
2. Air in Fuel System
3. Low Quality Fuel
4. Low Fuel Pressure
5. Fuel Injection Timing Not Correct
6. Valve Adjustment Not Correct
7. Bad Fuel Nozzle(s)
8. Low Compression

Exhaust Smoke Can Not Be Seen While Starting

Probable Cause(s)

9. No Fuel in Tank(s)
10. No Fuel From Fuel Injection Pump
11. Exhaust System Not Open

Difficult Starting

Engine Crankshaft Turns Freely

Exhaust Smoke Can Be Seen While Starting

Recommended Procedure

1. Cold Outside Temperatures . . . It may be necessary to use starting aids, or to heat engine oil or coolant at temperatures below 10°C (50°F).

2. Air in Fuel System . . . With air in the fuel system the engine will normally be difficult to start, run rough and release a large amount of white smoke. To remove the air from the fuel system, open the manual bleed valve on the fuel injection pump housing. Operate the priming pump until the flow of fuel from the manual bleed valve is free of air. Close the manual bleed valve and fasten the fuel priming pump. Start the engine. If the engine still does not run smooth or releases a large amount of white smoke, loosen the fuel line nuts one at a time at the cylinder heads, and permit the fuel to come out until it is free of air. Tighten the fuel line nuts. If air is not removed in this way, put 35 kPa (5 psi) of air pressure to the fuel tank.

NOTICE

Do not use more than 55 kPa (8 psi) of air pressure in the fuel tank or damage to the tank may result.

Check for leakage at the connections between the fuel tank and the fuel transfer pump. If leaks are found, tighten the connections or replace the lines. If there are no visual leaks, remove the fuel supply line from the tank and connect it to an outside fuel supply. If this corrects the problem, the suction line (standpipe) inside the fuel tank has a leak.

3. Low Quality Fuel . . . Remove a small amount of fuel from the tank and check for water in the fuel. If there is water in the fuel, remove fuel from the tank until it is free of water and fill with a good quality fuel. Change the fuel filter and "prime" (remove the air and/or low quality fuel from the fuel system) the fuel system with the fuel priming pump. If there is no water in the fuel, prime and start the engine by using an outside source of fuel. If engine starts correctly using different fuel, remove all fuel from the tank and fill with good quality fuel. Prime the fuel system if necessary.

4. Low Fuel Pressure . . . Change the fuel filter. If the pressure is still low, check the bypass valve in the fuel transfer pump. Debris in the system can make the valve become stationary in the open position.

5. Fuel Injection Timing Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual.

6. Valve Adjustment Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual. Intake valve clearance is 0.38 mm (.015 in) and exhaust valve clearance is 0.64 mm (.025 in).

7. Bad Fuel Nozzle(s) . . . Remove and test the fuel nozzles.

8. Low Compression . . . See Misfiring and Running Rough.

Exhaust Smoke Can Not Be Seen While Starting

9. No Fuel in Tank(s) . . . Check fuel level visually (do not use the fuel gauge only). Be sure tank selection valve is open to the tank with fuel in it. Be sure valve in fuel line between the tanks is open.

10. No Fuel From Fuel Injection Pump . . . Loosen a fuel injection line nut at the pump housing. With ignition switch in the ON position and accelerator in the FUEL ON position, turn the engine with the starter to be sure there is no fuel from the fuel injection pump. To find the cause for no fuel, follow Steps (a) through (d) until the problem is corrected.

a. Prime the fuel system as shown in Procedure No. 2.

b. Check shutoff solenoid by turning ignition switch to ON position. You must hear a sound when the plunger opens. If no sound is heard, make sure there is battery voltage at the solenoid. If the solenoid does not work, install a new solenoid.

c. If you are not using a good quality of fuel at temperatures below −12°C (10°F), it is possible that the fuel in the system can "wax" (not have correct flow characteristics) and cause a restriction in the fuel system. Install a new fuel filter. It may be necessary to drain the complete fuel system and replace with a No. 1 grade of fuel.

d. Check for fuel supply line restriction by removing the fuel supply line for the fuel filter base. Put 35 kPa (5 psi) of air pressure to the fuel tank.

NOTICE

Do not use more than 55 kPa (8 psi) of air pressure in the fuel tank or damage to the tank may result.

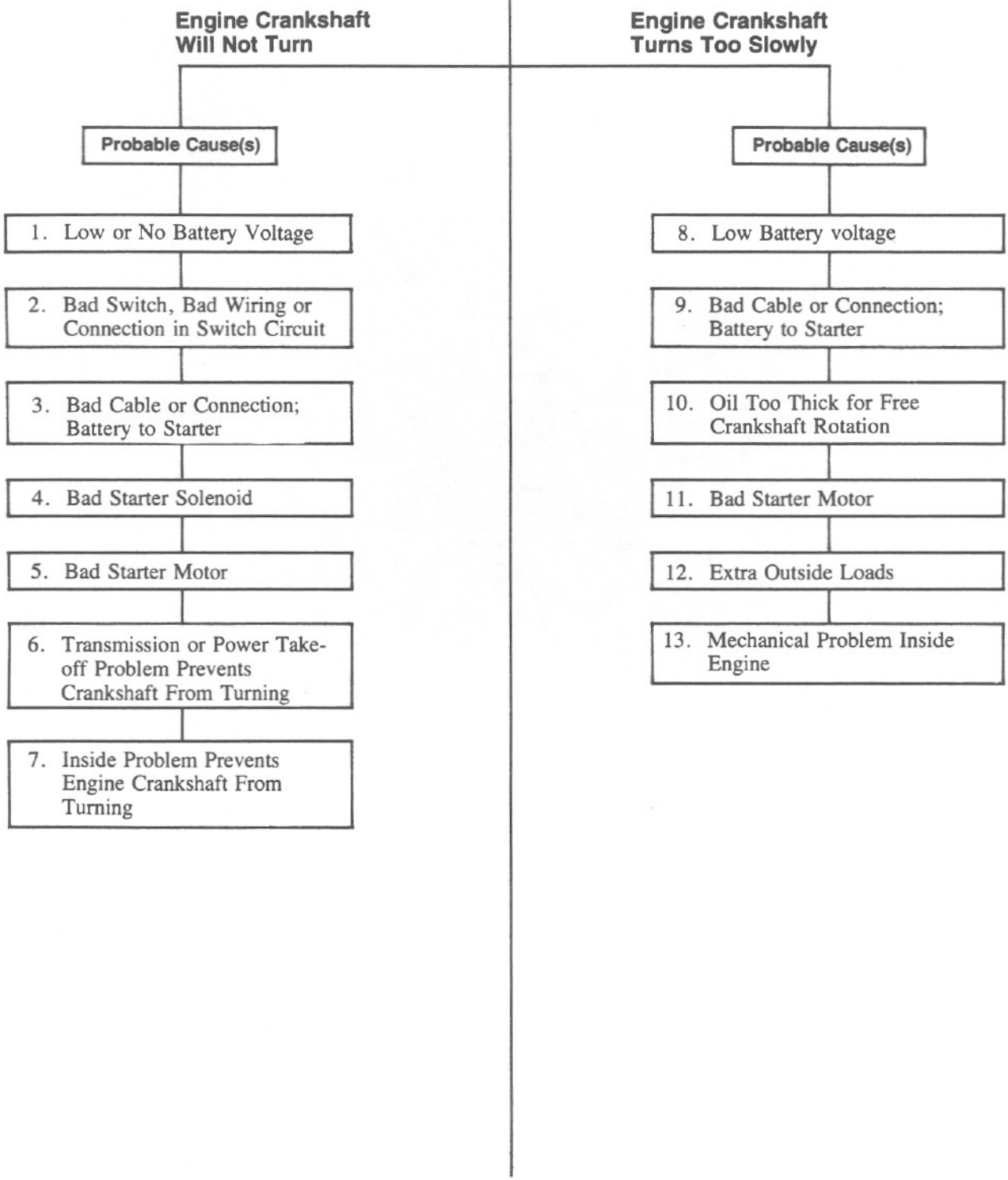
If there is no fuel, or only a weak flow of fuel from the fuel supply line, there is a restriction in the fuel supply line and/or the fuel tank.

11. Exhaust System Not Open . . . Loosen the exhaust pipe from the exhaust manifold. If engine will now start, check the exhaust system for damage and/or restrictions.

Difficult Starting

Engine Crankshaft Will Not Turn
Engine Crankshaft Turns Too Slowly

DIFFICULT STARTING



Difficult Starting

Engine Crankshaft Will Not Turn

Recommended Procedure

1. Low or No Battery Voltage . . . Check battery voltage. If battery voltage is less than 8 volts for a 12 volt system, or 16 volts for a 24 volt system, put a charge to the battery. If battery will not hold a charge, load test the battery as shown in the Electrical System of the Testing and Adjusting section of this Service Manual.

2. Bad Switch, Bad Wiring or Connection in Switch Circuit . . . With ignition switch in START position, check voltage at switch connection on starter solenoid. If there is no voltage, or if the voltage is low at this connection, check wiring, connections, ignition switch, and magnetic switch (if used).

3. Bad Cable or Connection; Battery to Starter . . . With ignition switch in the START position, check voltage at connection of battery cable to starter. If there is no voltage, or if the voltage is low at this connection and there is good voltage at the battery, check for bad cable or connection between the battery and the starter.

4. Bad Starter Solenoid . . . Remove and repair a solenoid which does not work when voltage is correct at both the battery and ignition switch connections.

5. Bad Starter Motor . . . If the solenoid works and the starter motor does not turn the crankshaft, the starter motor is bad. Before removing the starter motor, turn the crankshaft by hand to be sure a mechanical failure inside the engine, transmission, or power take-off is not preventing the crankshaft from turning. If crankshaft turns freely by hand, engage the starter motor again. If the starter motor still will not work, remove the starter motor and repair it, or install a new starter motor.

6. Transmission or Power Take-off (if so equipped) Problem Prevents Crankshaft From Turning . . . If crankshaft can not be turned by hand, disconnect the transmission and power take-off. If crankshaft will now turn, find the cause of the problem in the transmission or power take-off and make necessary corrections.

7. Inside Problem Prevents Engine Crankshaft From Turning . . . If the crankshaft can not be turned after disconnecting the transmission and power take-off, remove the fuel nozzles and check for fluid in the cylinders while turning the crankshaft. If fluid in the cylinders is not the problem, the engine must be disassembled to check for other inside problems. Some of these inside problems are bearing seizure, piston seizure, and valves making contact with pistons.

Engine Crankshaft Turns Too Slowly

8. Low Battery Voltage . . . Check battery voltage. If battery voltage is less than 8 volts for a 12 volt system, or 16 volts for a 24 volt system, put a charge to the battery. If the battery will not hold a charge, load test the battery as shown in the Electrical System of the Testing and Adjusting section of this Service Manual.

9. Bad Cable or Connection; Battery to Starter . . . With switch in START position, check voltage at battery cable connection to starter. If voltage is low at this connection and there is good voltage at the battery, check for bad cable or connection between the battery and the starter.

10. Oil Too Thick for Free Crankshaft Rotation . . . Use recommended Lubricant Viscosities as found in the Operation And Maintenance Guide.

11. Bad Starter Motor . . . Remove and test. Make repairs as necessary or install a new starter motor.

12. Extra Outside Loads . . . Damage to the power take-off equipment (if so equipped) and/or transmission can put extra load on the engine. This prevents free rotation of the crankshaft. To check, disconnect the transmission and power take-off, and start the engine.

13. Mechanical Problem Inside Engine . . . Take the engine apart and check all components for damage.

COOLING SYSTEM

Above Normal Heating

Probable Cause(s)

1. Low Coolant Level
2. Bad Temperature Gauge
3. Dirty Radiator
4. Loose Belt(s)
5. Bad Hose(s)
6. Shunt Line Restriction
7. Shutters Not Opening Correctly
8. Bad Water Temperature Regulators
9. Bad Water Pump
10. Air in Cooling System
11. Wrong Fan, Fan or Shroud Not in Correct Position
12. Radiator Too small
13. Not Enough Air Flow Through Radiator Because of Restriction in Engine Compartment
14. High Outside Temperature

Above Normal Heating (Cont.)

Probable Cause(s)

15. Operation at High Altitude
16. Engine Used in a Lug Condition
17. Air Inlet Restriction
18. Exhaust Restriction
19. Fuel Injection Timing Not Correct
20. Transmission Problems

Below Normal Heating

Probable Cause(s)

21. Long Idle Periods
22. Very Light Load
23. Bad Water Temperature Regulator(s) and/or Vent Valve

Cooling System

Above Normal Heating

Recommended Procedure

1. Low Coolant Level . . . If the coolant level is too low, not enough coolant will go through the engine and radiator. This lack of coolant will not take enough heat from the engine and there will not be enough flow of coolant through the radiator to release the heat into the cooling air. Low coolant level is caused by leaks or wrong filling of the radiator. With the engine cool, be sure that coolant can be seen at the low end of the fill neck on the radiator top tank.

2. Bad Temperature Gauge . . . A temperature gauge which does not work correctly will not show the correct temperature. If the temperature gauge shows that the coolant temperature is too hot but other conditions are normal, either install a gauge you know is good or check the cooling system with the 8T0470 Thermistor Thermometer Group.

3. Dirty Radiator . . . Check the radiator for debris between the fins of the radiator core which prevents free air flow through the radiator core. Check the radiator for debris, dirt, or deposits on the inside of the radiator core which prevents free flow of coolant through the radiator.

4. Loose Belt(s) . . . Loose fan belts will cause a reduction in air flow. Tighten the belts according to V-Belt Tension Chart that is shown in Specification section of this Service Manual.

5. Bad Hose(s) . . . Bad hoses with leaks can normally be seen. Hoses that have no visual leaks can "collapse" (pull together) during operation and cause a restriction in the flow of coolant. Hoses become soft and/or get cracks after a period of time. Hoses must be changed after 50,000 miles or a year of use. The inside of a hose can deterioriate, and the loose particles of the hose can cause a restriction in the flow of coolant.

6. Shunt Line Restriction . . . A restriction of the shunt line from the radiator top tank to the engine water pump inlet, or a shunt line not installed correctly, will cause a reduction in water pump efficiency. The result will be low coolant flow and overheating.

7. Shutters Not Opening Correctly . . . Check the opening temperature of the shutters. The shutters must be completely closed at a temperature below the fully open temperature of the water temperature regulators.

8. Bad Water Temperature Regulator(s) . . . A regulator that does not open, or only opens part of the way, can cause above normal heating. To test the thermostats, see the Testing and Adjusting section of this Service Manual.

9. Bad Water Pump . . . A water pump with a loose or damaged impeller does not pump enough coolant for correct engine cooling. Remove the water pump and check for damage to the impeller. If the impeller has no damage, check the impeller clearance. The clearance between the impeller and the housing is 0.28 to 0.84 mm (.011 to .033 in).

10. Air in Cooling System . . . Air can get into the cooling system in different ways. The most common causes are not filling the cooling system correctly, and combustion gas leaking into the system. Combustion gas can get into the system through inside cracks or bad cylinder head gaskets. Air in the cooling system causes a reduction in coolant flow and bubbles in the coolant. Air bubbles hold coolant away from engine parts, preventing heat flow.

Air in the cooling system can be found by the Bottle Test. The equipment needed to make this test is a one pint bottle, a bucket of water and a hose which will fit the end of the overflow pipe of the radiator.

Before testing, make sure the cooling system is filled correctly. Use a wire to hold the relief valve in the radiator cap open. Install the radiator cap and tighten it. Put the hose over the end of the overflow pipe.

Start the engine and operate it at high idle rpm for a minimum of five minutes after the engine is at normal operating temperature. Use a cover on the radiator core to keep the engine at operating temperature. After five or more minutes at operating temperature, place the loose end of the hose in the bottle filled with water. Put the bottle in the bucket of water with the top down. If the water gets out of the bottle in less than forty seconds, there is too much exhaust gas leakage into the cooling system. Find the cause of the air or gas getting into the cooling system and correct as necessary.

11. Wrong Fan, Fan or Shroud Not in Correct Position . . . A wrong fan, or a fan or shroud in a wrong position will cause a reduction or a loss of air flow through the radiator. The fan must be large enough to send air through most of the area of the radiator core. Make sure the fan size, fan shroud and position of fan and shroud are according to the recommendations of the Truck Manufacturer.

12. Radiator Too Small . . . A radiator which is too small does not have enough area to release the heat to the cooling air. This will cause the engine to run at higher than normal temperatures. Make sure the radiator size is according to the recommendations of the Truck Manufacturer.

13. Not Enough Air Flow Through Radiator Because of Restriction in Engine Compartment . . . The air flow through the radiator comes out of the engine compartment. Make sure the filters, air conditioners and similar items are not installed in a way which prevents free flow of air into and out of the engine compartment.

14. High Outside Temperature . . . When outside temperatures are too high for the rating of the cooling system, there is not enough temperature difference between the outside air and coolant temperatures. To get better cooling, use the truck in a lower gear.

15. Operation at High Altitude . . . The cooling capacity of the cooling system goes down as the truck is used at higher altitudes. A system, under pressure, large enough to keep the coolant from boiling must be used.

16. Engine Used in a Lug Condition . . . "Lugging" (when the truck is used in a gear too high for engine rpm to go up as accelerator pedal is pushed farther down, or when the truck is used in a gear where engine rpm goes down with accelerator pedal at maximum travel) the engine causes the engine rpm and fan rpm to be low. This low rpm causes a reduction in air flow through the radiator, and a reduction in the flow of coolant through the system. This combination of less air and less coolant flow during high input of fuel will cause above normal heating.

17. Air Inlet Restriction . . . Restriction of the air coming into the engine causes high cylinder temperatures and more than normal amount of heat to pass to the cooling system. Check for a restriction with a water manometer or a vacuum gauge (which measures in inches of water). Connect the gauge to the engine air inlet between the air cleaner and the inlet to the turbocharger. With gauge installed, run engine at full load rpm and check the restriction. Maximum restriction of air inlet is 635 mm (25 in) of water. If the indication is higher than the maximum permissible restriction, remove the dirt from the filter element, or install a new filter element and check the restriction again. If the indication is still too high, there must be a restriction in the inlet piping.

18. Exhaust Restriction . . . Restriction in the exhaust system causes high cylinder temperatures and more than normal amount of heat to pass to the cooling system. To see if there is an exhaust restriction, make a visual inspection of the exhaust system. Check for damage to piping or for a bad muffler. If no damage is found, check the system for back pressure from the exhaust (pressure difference measurement between exhaust outlet and atmosphere). The back pressure must not be more than 1016 mm (40 in) of water. You can also check the system by removing the exhaust pipes from the exhaust manifolds. With the exhaust pipes removed, start and run the engine to see if the problem is corrected.

19. Fuel Injection Timing Not Correct . . . Check and make necessary adjustments as per Testing and Adjusting section of this Service Manual.

20. Transmission Problems . . . Power-shift or automatic transmissions that are cooled by the engine cooling system can cause above normal heating if they are out of adjustment or not working correctly. See the transmission Service Manual for the correct adjustments.

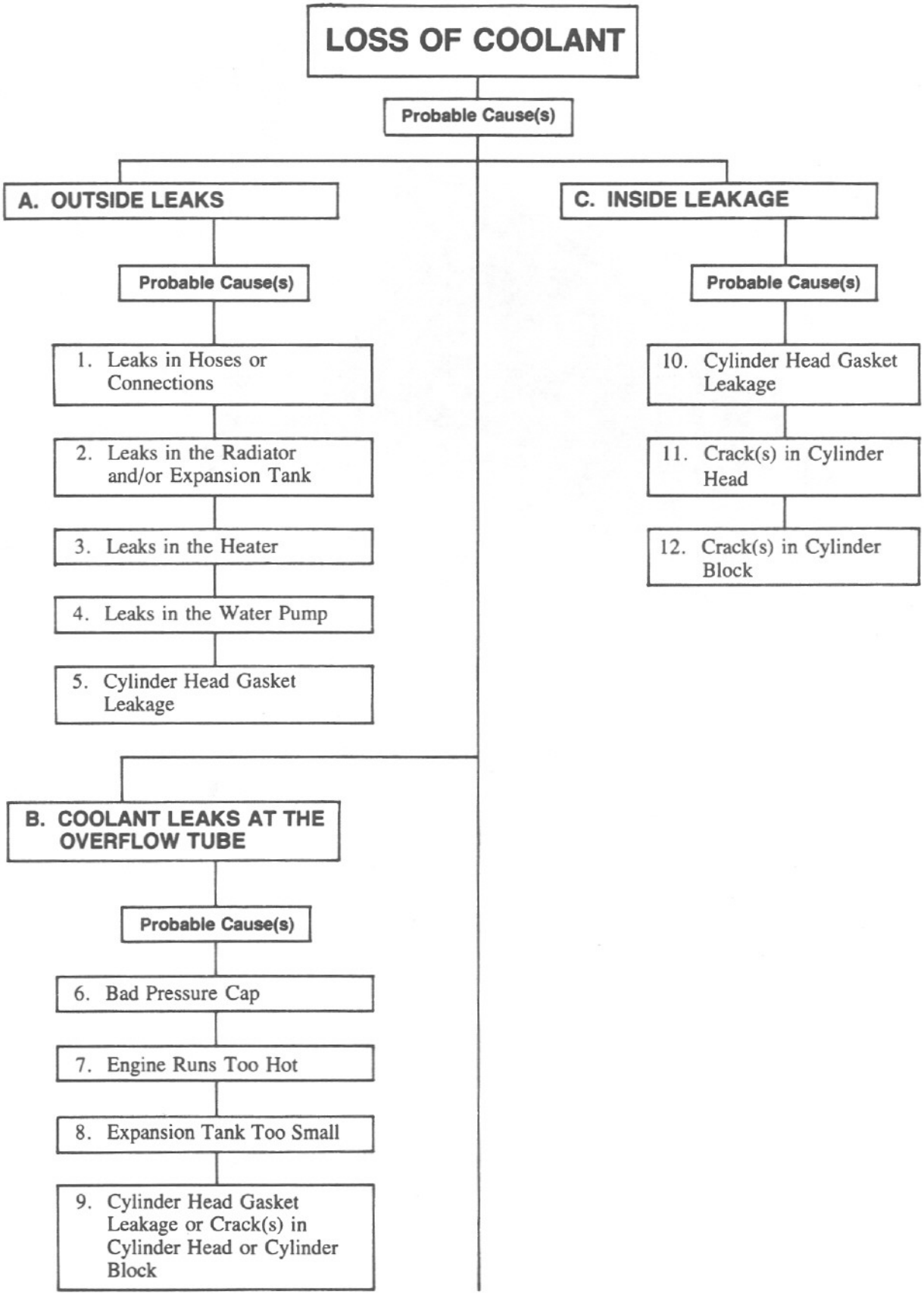
Below Normal Heating

21. Long Idle Periods . . . When the engine is running with no load, only a small quantity of fuel is burnt and engine heat is removed too fast.

22. Very Light Load . . . Very light loads, and a very slow speed or downhill travel can cause below normal heating because of the low heat input of the engine. The installation of shutters helps to correct this condition.

23. Bad Water Temperature Regulator(s) and/or vent valve . . . A regulator that is "stuck" open (will not move to the closed position) will cause below normal heating. A regulator that is stuck between the open and closed positions, or a vent valve that is stuck open, can cause below normal heating when the truck has a light load.

Loss Of Coolant


LOSS OF COOLANT
Probable Cause(s)
A. OUTSIDE LEAKS
Probable Cause(s)
1. Leaks in Hoses or Connections
2. Leaks in the Radiator and/or Expansion Tank
3. Leaks in the Heater
4. Leaks in the Water Pump
5. Cylinder Head Gasket Leakage
B. COOLANT LEAKS AT THE OVERFLOW TUBE
Probable Cause(s)
6. Bad Pressure Cap
7. Engine Runs Too Hot
8. Expansion Tank Too Small
9. Cylinder Head Gasket Leakage or Crack(s) in Cylinder Head or Cylinder Block
C. INSIDE LEAKAGE
Probable Cause(s)
10. Cylinder Head Gasket Leakage
11. Crack(s) in Cylinder Head
12. Crack(s) in Cylinder Block

Loss of Coolant

Recommended Procedure

A. **Outside Leaks**

1. Leaks in Hoses or Connections . . . Check all hoses and connections for visual signs of leakage. If no leaks are seen, look for damage to hoses or loose clamps.

2. Leaks in the Radiator and/or Expansion Tank . . . Put pressure to the radiator and/or expansion tank with the 9S8140 Cooling System Pressurizing Pump Group and check for leaks.

3. Leaks in the Heater . . . Put pressure to the cooling system with the 9S8140 Cooling System pressurizing Pump Group and check the heater for leaks.

4. Leaks in the Water Pump . . . Check the water pump for leaks before starting the engine, then start the engine and look for leaks. If there are leaks at the water pump, repair or install a new water pump.

5. Cylinder Head Gasket Leakage . . . Look for leaks along the surface of the cylinder head gasket. If you see leaks, install a new head gasket.

B. **Coolant Leaks at the Overflow Tube**

6. Bad Pressure Cap or Relief Valve . . . Check the sealing surfaces of the pressure cap and the radiator to be sure the cap is sealing correctly. Check the opening pressure and sealing ability of the pressure cap or relief valve with the 9S8140 Cooling System Pressurizing Pump Group.

7. Engine Runs Too Hot . . . If coolant temperature is too high, pressure will be high enough to move the cap off of the sealing surface in the radiator and cause coolant loss through the overflow tube. See "Above Normal Heating" in COOLING SYSTEM Chart.

8. Expansion Tank Too Small or Installed Wrong . . . The expansion tank can be either a part of the radiator or it can be installed separately from the radiator. The expansion tank must be large enough to hold the expansion of the coolant as it gets warm or has sudden changes in pressure. Make sure the expansion tank is installed correctly, and the size is according to the recommendations of the Truck Manufacturer.

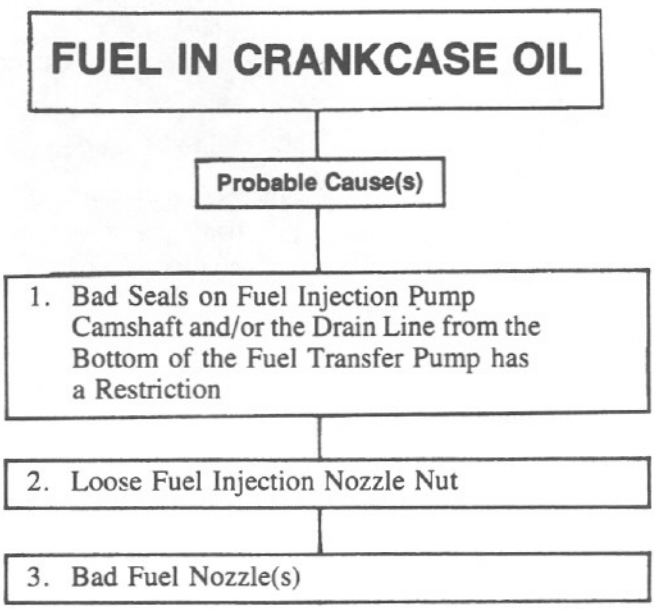
9. Cylinder Head Gasket Leakage, or Crack(s) in Cylinder Head or Cylinder Block . . . Remove the radiator cap and with the engine running look for air bubbles in the coolant. Bubbles in the coolant are a sign of probable leakage at the head gasket. With the engine not running, check each cylinder with the cylinder leakage tester. Special Instruction, Form No. GMG00694 gives the test procedure. If you see air bubbles in the coolant during this test, there is a leak of combustion gas into the cooling system. Remove the cylinder heads from the engine. Check cylinder heads, cylinder walls and head gasket surface of the cylinder block for cracks. When installing heads, use new head gasket.

C. **Inside Leakage**

10. Cylinder Head Gasket Leakage . . . If the cylinder head gasket leaks between a water passage and an opening into the crankcase, coolant will get into the crankcase.

11. Crack(s) in Cylinder Head . . . Crack(s) in the upper surface of the cylinder head, or an area between a water passage and an opening into the crankcase, can allow coolant to get into the crankcase.

12. Crack(s) in Cylinder Block . . . Crack(s) in the cylinder block between a water passage and the crankcase will let coolant get into the crankcase.


FUEL IN CRANKCASE OIL
Probable Cause(s)
1. Bad Seals on Fuel Injection Pump Camshaft and/or the Drain Line from the Bottom of the Fuel Transfer Pump has a Restriction
2. Loose Fuel Injection Nozzle Nut
3. Bad Fuel Nozzle(s)

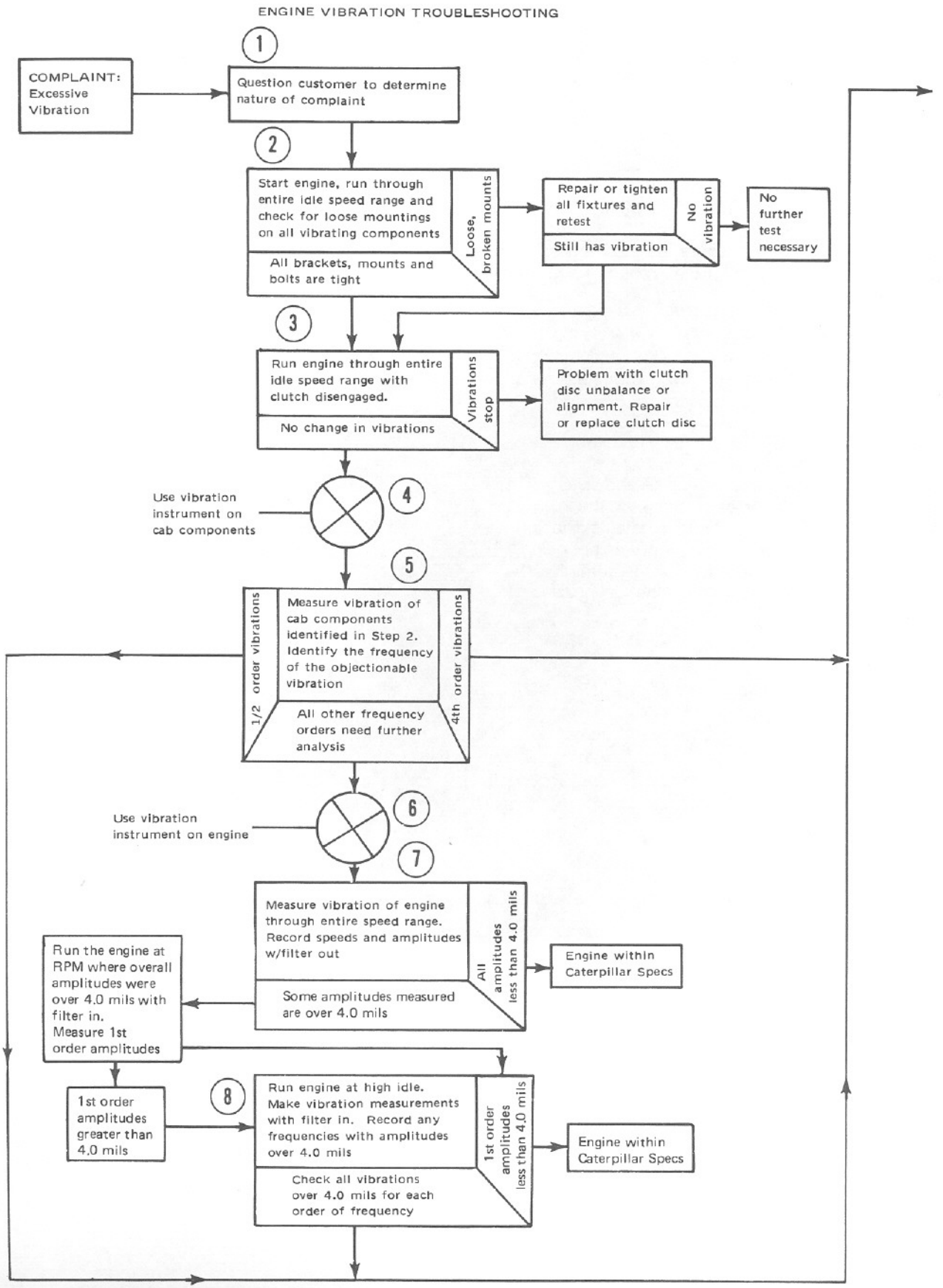
Fuel in Crankcase Oil

Recommended Procedure

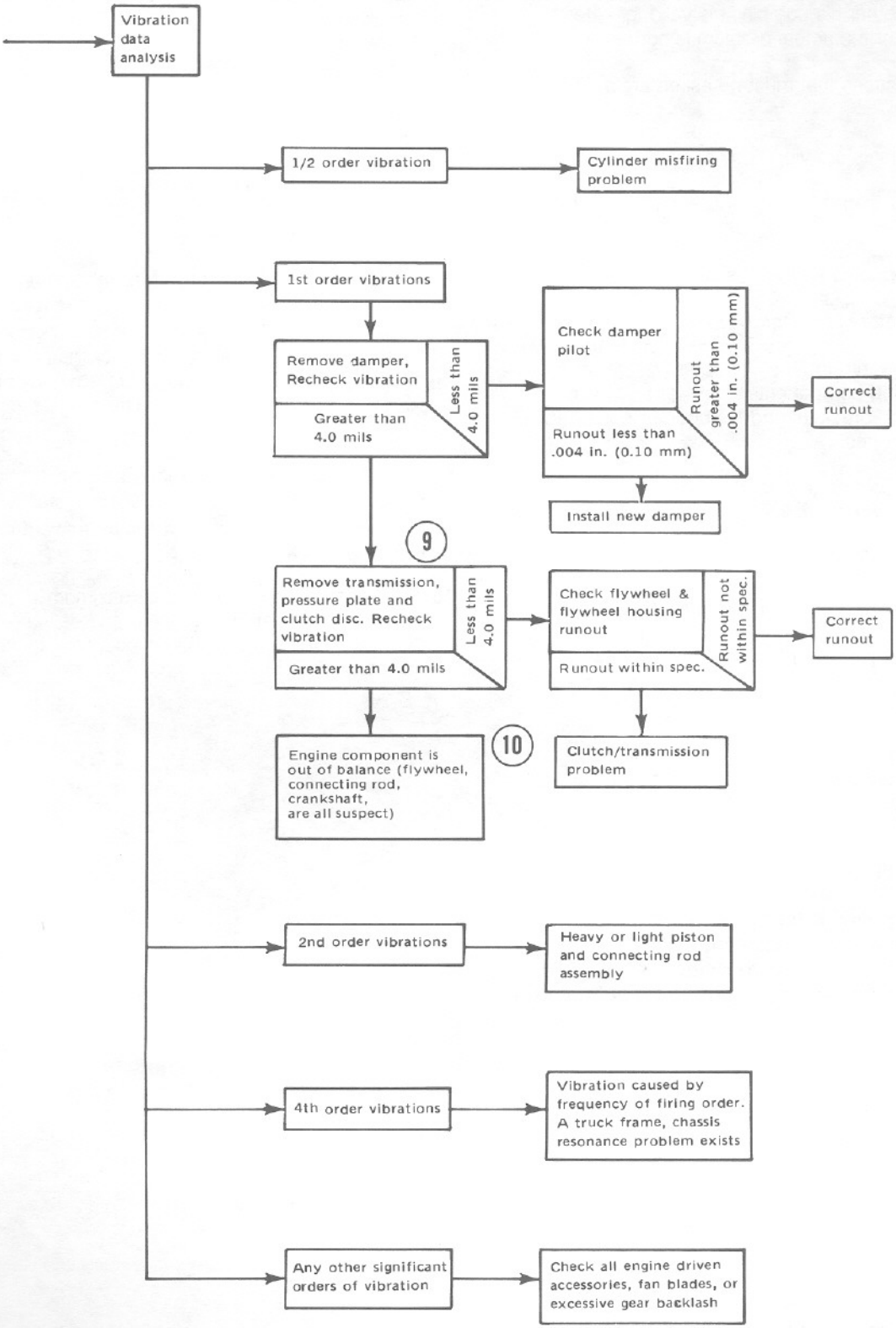
1. Bad Seals on Fuel Injection Pump Camshaft and/or the Drain Line from the bottom of the Fuel Transfer Pump has a Restriction . . . If both seals on the fuel pump camshaft in the body for the fuel transfer pump and/or the drain line from the bottom of the fuel transfer pump has a restriction the fuel can leak by the seals directly into the engine. To correct, install new seals in the body for the fuel transfer pump and be sure the drain line is open.

2. Loose Fuel Injection Nozzle Nut(s) . . . A loose fuel injection nozzle nut or a bad O-ring seal on the nozzle inlet can cause fuel leakage. Tighten nozzle nut(s) to 42 ± 7 N•m (31 ± 5 lb ft) and check for a bad O-ring seal.

3. Bad Fuel Nozzle(s) . . . Check fuel nozzle(s) for cracks in inlet fitting, inlet line, or nozzle body. If you do not see a crack, start the engine and visually inspect each nozzle for leaks. Cracks in the inlet fitting and nozzle body are nozzle defects. Cracks in the inlet line are caused by the nozzle not being tightened correctly. Check for leakage at the fuel nozzle cap. If no leakage is seen the fuel nozzles can be removed and checked.


ENGINE VIBRATION TROUBLESHOOTING
COMPLAINT: Excessive Vibration
1
Question customer to determine nature of complaint
2
Start engine, run through entire idle speed range and check for loose mountings on all vibrating components
Loose, broken mounts
Repair or tighten all fixtures and retest
No vibration
Still has vibration
No further test necessary
All brackets, mounts and bolts are tight
3
Run engine through entire idle speed range with clutch disengaged.
Vibrations stop
Problem with clutch disc unbalance or alignment. Repair or replace clutch disc
No change in vibrations
Use vibration instrument on cab components
4
5
1/2 order vibrations
Measure vibration of cab components identified in Step 2. Identify the frequency of the objectionable vibration
4th order vibrations
All other frequency orders need further analysis
Use vibration instrument on engine
6
7
Measure vibration of engine through entire speed range. Record speeds and amplitudes w/filter out
All amplitudes less than 4.0 mils
Engine within Caterpillar Specs
Some amplitudes measured are over 4.0 mils
Run the engine at RPM where overall amplitudes were over 4.0 mils with filter in. Measure 1st order amplitudes
1st order amplitudes greater than 4.0 mils
8
Run engine at high idle. Make vibration measurements with filter in. Record any frequencies with amplitudes over 4.0 mils
1st order amplitudes less than 4.0 mils
Engine within Caterpillar Specs
Check all vibrations over 4.0 mils for each order of frequency

ENGINE VIBRATION TROUBLESHOOTING (Con't)



Engine Vibration Troubleshooting

1. The customer must be asked questions to determine whether his complaint is valid, or whether his diagnosis of the actual problem is correct.

Some of the questions that must be asked are as follows:

a. What components are vibrating?

b. In what speed range does this vibration become excessive?

c. Does clutch operation affect the vibration?

d. What is the history of the problem?

2. Run the engine through the idle speed range and note all vibrating components. Look for any loose or broken mounts, brackets and fasteners. Repair and tighten any fixtures.

3. Check idle speed range with clutch disengaged. If vibrations subside, there is a balance problem with the clutch disc. The clutch disc must be repaired or replaced.

4. Further analysis requires the use of a vibration instrument. Any instrument which can accurately measure the displacement of the vibration (usually in mils-inch/1000) and the frequency (cycles per minute) will be sufficient.

NOTE: A vibration instrument such as the IRD Mechanalysis Model 320 or an equivalent instrument can be used to analyze vibration.

5. Measure vibration of cab components which have the objectionable vibration.

Run engine slowly through the speed range and measure vibration with the instrument filter OUT. When peak amplitudes are found, run the engine at the speeds they occur and with the instrument filter IN, find the frequency of the vibration.

If the frequency of vibration is ½ times of engine rpm (½ order), the vibration is caused by a cylinder misfiring. This must be corrected before further vibration analysis is made.

If the frequency of vibration is 4 times engine rpm, no corrective action can be taken on the engine because this is the firing frequency of the 3208 Engine. The problem is in the cab or chassis resonance.

If frequency is some order other than ½ or 4th, then further measurements must be made on the engine.

6. Measurements taken on the engine must be made perpendicular to the crankshaft at the front and rear of the engine in vertical and horizontal directions.

7. Record all vibrations over 4.0 mils and the engine rpm at which it occurs (100 rpm intervals are sufficient) with instrument filter OUT. Note any sudden increase and decrease in amplitudes. These occur in resonant speed ranges.

If no amplitudes exceed 4.0 mils, the engine is within Caterpillar Specs.

If amplitudes exceed 4.0 mils, the vibrations must be measured with the instrument filter IN to obtain the frequency of the vibrations.

8. Run the engine at high idle. With the instrument filter IN, check the frequency range and record any amplitudes over 4.0 mils and the corresponding frequency. Analysis of vibrations for the possible causes is done by identifying the frequency of the vibration and where on the engine it is the greatest magnitude.

9. Before vibration is rechecked, rotate the crankshaft to No. 1 cylinder top center position. Install a ⅜-16 bolt 1¾" long with a nut into the flywheel at the 9 o'clock position.

10. The location on the engine at maximum vibration (front or rear) can help pinpoint the cause of the vibration. High rear vibrations could be caused by the flywheel.