16 DIAGNOSTIC ANALYSIS

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16.1 DEFINITION

Diagnostic analysis involves certain checks that are simple and easily performed. These checks usually reveal the most frequently encountered causes of faulty operation. The data obtained must be related to the complaint. A failure may be due to a chain of conditions that no one thought important enough to report. The repair must include the discovery of the true cause of the complaint and the corrective measures necessary to correct the condition.

The key to successful diagnostic analysis is the mental matching of the information of the condition with a complete knowledge of how the engine and all its components operate and their inter–relationship.

16.2 DIAGNOSTIC ANALYSIS PROCEDURES

16.2.1 Oil Consumption

When analyzing a lube oil consumption problem proceed as follows:

1. Visually inspect for external leaks and correct.

2. Check for air cleaner restriction, air induction system leaks and excessive crankcase pressure.

NOTE:
Change the oil filter element and inspect the turbocharger for damage if lube oil is drawn into the engine.

If items 1 and 2 are NOT the cause, continue analysis.

3. Verify the problem:

   a. Change the oil (using the recommended API Specification and viscosity for the ambient temperature).

   b. Determine initial oil consumption rate and trend at:

      1000 miles/50 hours
      or
      5000 miles/250 hours

   c. Record the amount of make up lube oil added during the test period.

NOTE:
Verify the engine is equipped with the proper dipstick. The wrong dipstick may result in erroneous reading.

NOTE:
Lube oil level must be "topped" [with engine hot, after a 15 min. shutdown period], at the beginning and at the end of each oil consumption test period.

4. If oil consumption was excessive, determine the cause of the problem:

   a. Abnormally heavy loads pulled by the vehicle.

   b. Improper operation (i.e. allowing the engine to lug in the incorrect gear range) resulting in oil consumption.

   c. Faulty air compressor. (If compressor piston rings are worn, oil can be forced into the air system.)

   d. Worn engine valve guides or valve stem seals. (Clean, inspect and replace if required.)

   e. Worn rings and/or bores due to normal wear or dirt passing the air filter element.

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16.2.2 Fuel Consumption

1. When excessive fuel consumption is suspected, verify the problem:
   a. Compare the actual rate of consumption in miles per gallon against normal expected fuel usage in the subject vehicle.
   b. If excessive fuel consumption is confirmed, determine the cause of the problem.
2. Check the entire fuel system (tank to injection pump) for leaks.
3. Investigate the possibility that the engine is not in proper specs for the application by conducting the diagnostic tests indicated in the text.
4. Review the driver's habits to be sure he is not lugging or overspeeding the engine.
5. Inspect the engine per the "Performance Data Guidelines" listed in Section 20.

16.2.3 High Coolant Temperature Or Loss

1. Verify problem:
   a. Determine operating conditions when over heating occurs.
   b. Refer to guideline temperature data in the "Performance Data Guidelines" located in Section 20.
   c. Check the following items:
      - Filler cap [pressure cap] on deaeration tank.
      - External Leaks [pressurize system].
      - Coolant solution [glycol contamination].
      - Serpentine belt and tensioner.
      - Dash gauge and sender accuracy/calibration.
      - Thermostat operation [stuck or near closed].
      - Radiator cleanliness [inside and out].
      - Shutter operation [if equipped].
      - Air flow blockage [winter front etc.]
2. Verify operation:
   a. Operator's habits – running improper range.
   b. Vehicle specifications – verify the guideline data is correct for the vehicle and job.
   c. Accessory equipment – is the equipment approved and installed correctly?
3. Engine maintenance:
   a. Clean, no oil leaks, no external coolant leaks.
   b. Condition of serpentine belt and tensioner.
4. Inspect cooling system:
   a. Coolant must be clean and properly inhibited for the season.
   b. Deaeration tank (pressure) cap operation. Use pressure test kit Model D200 (J39257). Check restriction at water pump inlet. Should not exceed 3 in. Hg (10 kPa) without pressure cap, thermostat open and engine at high idle.
   c. Hoses – correct type and properly clamped.
   d. Radiator clean and unobstructed by bent fins, pinched tubes, etc.

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e. Radiator correct. Check repair history or use of "stop leaks". Check specifications of radiator for vehicle.

f. Fan – proper specification for vehicle, proper fit in shroud. Properly installed.

g. Shutter control (if equipped) operative and correctly set.

5. Inspect engine:

   a. Water pump condition.

   b. Thermostat and seal – proper specifications and operating correctly.

   c. Static timing.

   d. Engine power correct.

   e. Coolant aeration from head gasket or nozzle sleeve leakage or a cracked/porous cylinder head.

16.2.4 Combustion Leakage – The Pop Bottle Test

1. Inspect the deaeration tank (pressure) cap gasket and the deaeration tank filler neck seat for damage to insure that leakage will not occur.

2. Check the overflow pipe for damage.

3. Fill the coolant deaeration tank to the top of the filler neck which is beyond the normal fill capacity.

4. With the engine at operating temperature, operating at low idle speed, the thermostat fully opened and the cooling system purged of air, fill the test bucket and pop bottle with water.

5. Immerse the filled pop bottle in the bucket of water with the filler neck facing the bottom of the bucket as shown in **FIGURE 16–1.**

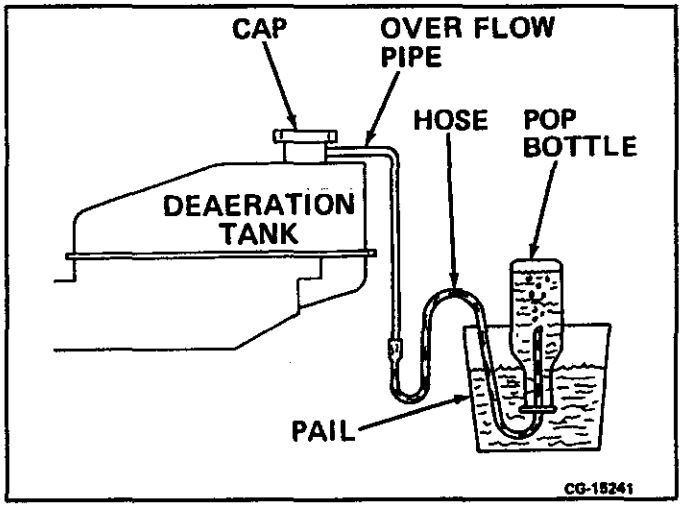

FIGURE 16–1 Combustion Leakage Test and Connections

6. Insert the overflow line extension into the bottle neck.

7. Observe the pop bottle for aeration (bubbles or in extreme cases the water in the pop bottle will be blown out).

NOTE:

Bubbles or expulsion of water from bottle indicate head gasket or nozzle sleeve leakage or a cracked or porous cylinder head.

16.2.5 Excessive Exhaust Smoke

Excessive visual smoke can occur under two separate general conditions:

- ❑ During acceleration
- ❑ During full load operation

Excessive visual exhaust smoke can be caused by improper operation of the vehicle. For example, the driver must keep the engine speed within the specified r/min range for the transmission and rear axle ratio.

Diagnosis of this problem is critical.

a. Check the air induction system and air cleaner restriction.

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b. Inspect the turbocharger for signs of lube oil leakage in the compressor housing.

c. Inspect the cooling system; overcooling can cause blue smoke.

d. Excessive lube oil consumption can cause blue smoke.

e. Constant gray smoke can be caused by poor injection nozzle condition or the air induction system. Refer to Section 19 for test procedures.

f. BLACK SMOKE – must be immediately corrected.

g. If the problem cannot be resolved by analysis, remove the injection pump for a test stand analysis.

h. WHITE SMOKE – May indicate excess fuel on cold start with insufficient cranking speed.

In general, any excess smoke problem can be resolved by following the procedures in the appropriate "Performance Analysis Guide".

16.2.6 Low Power

1. Verify the problem:

   a. Determine how power or performance is checked.

   b. Compare to identical units in same type operation. (Refer to "Performance Data Guidelines", Section 20).

2. Determine the cause of the problem:

   a. Check fuel type and grade. Refer to appropriate Operation and Maintenance manual.

   b. Inspect shutoff cable or electric shutoff for proper adjustment.

   c. Inspect the throttle cable for full travel from low idle stop to high idle stop under all conditions of operation. Make certain the operation of the vehicle is not changing these adjustments. Verify high idle.

   d. Inspect throttle cable over–travel at wide open throttle with engine running. Refer to Section 19 for procedure.

NOTE:

Throttle cable over–travel is the adjustment made on the throttle cable which compensates for wear that occurs in the throttle linkage and for chassis movement. If throttle cable over–travel is not maintained, full throttle and consequently, maximum performance will not be available.

   e. Measure transfer pump pressure.
      - Change filter if pressure is low
      - Check for fuel inlet restriction if new fuel filter did not correct the low transfer pump pressure.
      - If fuel inlet is not being restricted and fuel pressure is still low replace fuel return valve or transfer pump.

   f. Measure air cleaner restriction. Service air cleaner element(s) as necessary

   g. Check injection pump timing and correct with injection pump on engine.

   h. Loss of one cylinder.
      - Check for plugged injection line
      - Check nozzle operation

   i. Intake manifold pressure loss or aneroid diaphragm leakage.

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- Pressurize intake system and inspect for leaks at all (boost pressure) connections. Air leakage may occur at line connectors or on the boost line to the aneroid. During engine operation leaks at the connectors can cause manifold pressure to be reduced at the aneroid which allows the injection pump to operate in "cut back" or reduced power level.
- Test aneroid diaphragm by applying (20 lb/in.^{2} max.) air pressure, using the D–200 Pressure Test Kit, for 30 seconds. If leakage occurs, replace diaphragm. Low power and low manifold pressure will result if diaphragm leaks because injection pump will stay in "cut back" position.

16.2.7 Fuel Dilution

1. When fuel dilution is suspected, a sample of the lubricating oil should be taken to an independent lab to determine if oil has been diluted with fuel.
2. Lubricating oil may be diluted by fuel oil passing from the injection pump supply pump or internal seals. Follow the policies in effect on in–warranty engines.

16.2.8 Coolant In Lubricating Oil Or Lubricating Oil In Coolant

1. Pressure check oil cooler with oil cooler test plate. Refer to engine service manual for pressure check procedure.

The **possible locations of leakage** are:

a. Lube oil cooler bundle – [cracked or loose tubes]

b. Lube oil cooler O–rings – [damaged/ leaking]

2. If oil cooler is ok perform Pressure (Leakage) Test.

16.2.9 Pressure (Leakage) Test Procedure Engine Crankcase

1. Drain all lube oil and coolant from engine and radiator.
2. Disconnect the radiator from the engine and cap off all the engine connections (with hose clamps and plugs).
3. Disconnect the unit's cab heater connections at the engine and cap engine openings.
4. Disconnect air compressor coolant supply and discharge line, then cap lines at engine.
5. Remove the valve cover/intake manifold and lube oil pan.

NOTICE: **Do not loosen or remove any injection nozzles from the cylinder head while the cooling system is under pressure. Engine damage may occur.**

6. Fill the engine with water and attach an air line connection coupled with a regulator assembly to the water drain in cylinder block.
7. Pressurize the crankcase cooling system to 30 lb/in.^{2}. Pressure must be maintained until

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leakage location is evident. It may be necessary for the engine to remain pressurized over night to locate porous castings or tiny cracks.

8. It is essential that all points of leakage identified prior to teardown and repair. NO EXTERNAL OR INTERNAL LEAKAGE IS ALLOWABLE.

The **possible locations of leakage** are:

1. Cracked or porous cylinder head – top deck, core plug area or blown head gasket.
2. Porous crankcase.
3. Lower cylinder sleeve O–ring area. [Damaged or eroded.]
4. Blown air compressor head gasket.

When the location of the leak is found and repaired clean the contaminated engine with Butyl Cellosolve or Butyl Jaysolve (only if coolant leaked into the lube oil) as directed.

16.2.10 High Intake Manifold Pressure (Excessive Fuel Consumption)

Determine cause:

1. Overfueling of engine due to defective or misadjusted fuel injection pump.
2. Incorrect turbine housing (A/R ratio).
3. Incorrect nozzles – orifice size larger than specified for application.
4. Wastegate actuator failure.

16.2.11 Excessive Crankcase Pressure

Determine cause:

1. Worn piston/sleeve due to dirt.
2. Broken piston rings due to wear.
3. Stuck piston rings due to incorrect specification lube oil.
4. Worn or broken air compressor piston rings.
5. Turbocharger seal failure.
6. Excessive valve guide wear.
7. Intake manifold boost pressure leaking past intake manifold/valve cover gasket.

16.2.12 Low Fuel Supply Pressure

Determine cause:

1. Broken or plugged fuel strainer.
2. Restricted fuel filter element.
3. Restricted or leaking low pressure fuel lines from fuel tank to inlet of supply pump.
4. Defective supply pump (transfer pump) – regulative valve inoperative.
5. Defective fuel return valve.

16.2.13 Excessive Engine Speed

Determine cause:

1. Inaccurate tachometer.
2. Misadjusted injection pump.
3. Defective injection pump.
4. Overfueling of engine from oil carry over thru the turbocharger.

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16.2.14 Excessive Air Inlet Restriction

Determine cause:

1. Dirty element – soot – poor maintenance.
2. Damaged element.
3. Incorrect size element.
4. Damaged inlet piping.

16.2.15 Short Fuel Filter Life

1. Poor quality fuel (contaminated fuel).
2. Use of substandard fuel filters.

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17 ENGINE PERFORMANCE ANALYSIS GUIDES

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17.1 INTRODUCTION

Accurate diagnosis assures customer satisfaction by avoiding unnecessary repairs and expense. No doubt almost any mechanical problem can be accurately diagnosed under ideal conditions. But what really matters is whether accurate diagnosis can become the norm under everyday conditions. Much of the long term success and acceptance of an engine is actually determined by the efficiency of thousands of shop foremen and mechanics. The Engine Performance Analysis Guides are useful to the mechanic. It is not a form that remains buried in a book in the shop foreman's service library. The Performance Analysis Guide comes in pads of 50 sheets. The mechanic takes it right to the job with him and he uses it as a check list. The Performance Analysis Guide begins with those items which are easiest to check, and progress through the items for which the procedure to check is more involved.

Beginning with the basics, those items which are more common, and progressing to the less likely causes of a malfunction promotes RAPID as well as ACCURATE diagnosis when using the Performance Analysis Guide.

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17.2 INSTRUCTIONS FOR PERFORMANCE ANALYSIS GUIDES

Before starting any diagnostic work, complete all the information required at the top of the "Performance Analysis Guide" Form No. **7SE416, FIGURE 17–1.**

NOTICE: **If the injection pump is changed, the serial number of the pump being installed, as well as the serial number of the pump being replaced, must be recorded.**

Fill in the "Guideline Data" box on Engine Performance Analysis Guide (**FIGURE 17–1**) For The Specific Application, As Required. Locate the "Performance Data Guidelines" in Section 20. Make all static inspections [engine stopped]

NOTE:

Record the test data in the "1st Check" box. If there are any differences between the "Guideline Data" box and the "1st Check" box, correct as necessary and repeat the checks. Retain this information for future operating analysis. Always perform the "2nd Check" after engine repairs or injection pump change to confirm that the engine is performing properly.

Examples of engine repairs where the "2nd Check" must be made are injection pump changes, low power repairs, oil consumption repairs, etc.

Each Performance Analysis Guide has engine diagnostic test data boxes on one side and illustrations on the reverse side. The illustrations aid in proper test execution.

REGION	DEALER	ALTITUDE	AMBIENT AIR TEMP	DATE

CHASSIS MODEL	ENGINE MODEL	ENGINE H.P.	RATED SPEED	COMPLETE ENGINE SERIAL NUMBER	TRUCK MILEAGE	HOURS (if equipped)

PUMP PART NO.	PUMP SERIAL NUMBER (AS RECEIVED)	REPLACEMENT PUMP SERIAL NUMBER	VIN	MILEAGE ON ENGINE	HOURS (if equipped)

FROM PERFORMANCE ANALYSIS GUIDE

	LOW IDLE (RPM)*			
6	**A. MANUAL TRANSMISSION – NEUTRAL.** **B. AUTOMATIC TRANSMISSION – DRIVE.**			
	INSTRUMENT	**GUIDELINE DATA †**	**1st CHECK**	**2nd CHECK**
	MASTER TACHOMETER			

FIGURE 17–1 Performance Analysis Guide

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17.3 ENGINE TEST NOMENCLATURE

This section discusses the nomenclature used in engine testing.

17.3.1 Injection Pump Timing

Injection pump static timing is checked with the engine stopped — NOT RUNNING. The engine must be rotated so the #1 piston is at the top of its compression stroke and the timing mark on the vibration damper is in alignment with the timing mark on the timing indicator

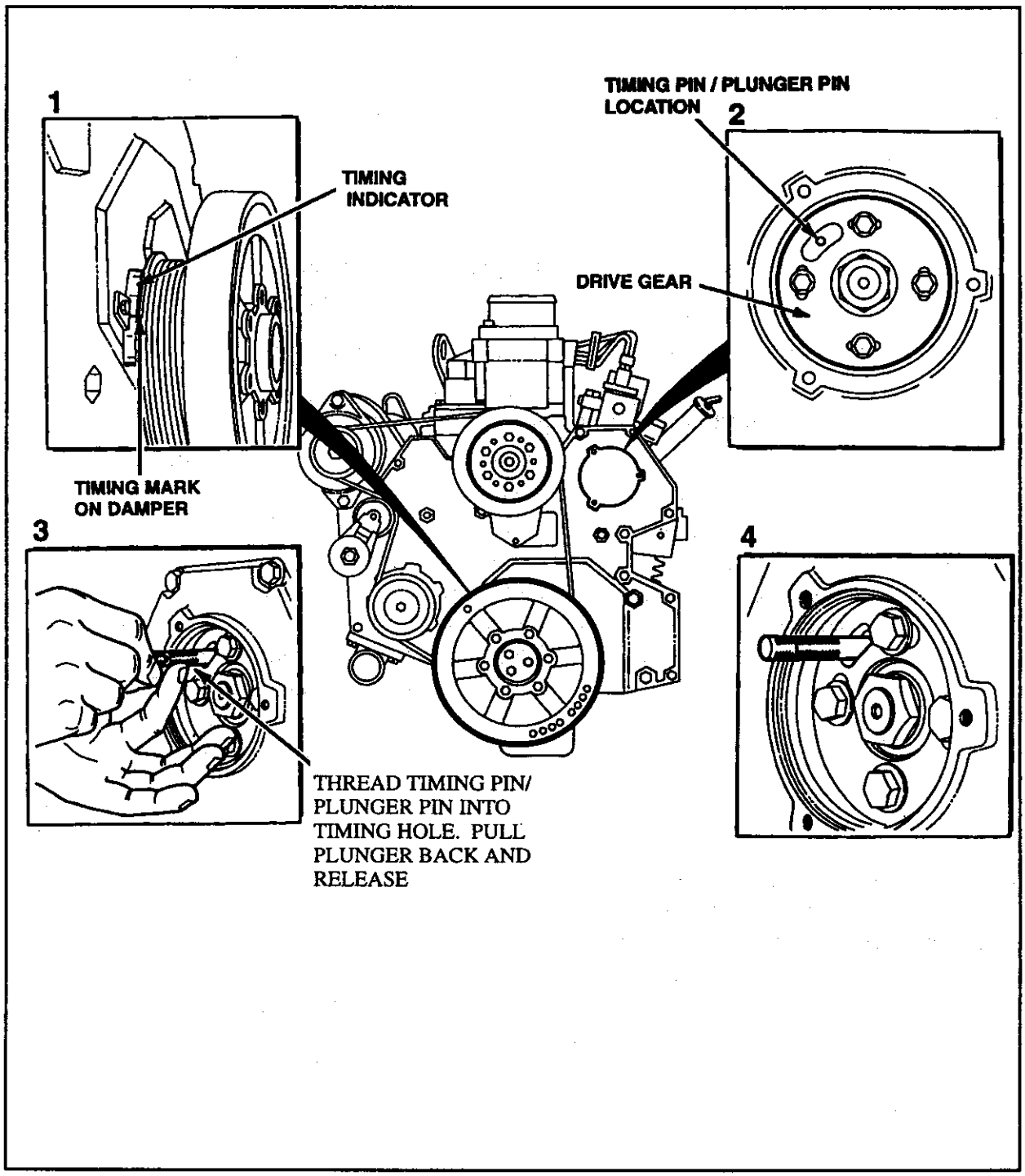

FIGURE 17–2 Injection Pump Timing Verification

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ENGINE TEST NOMENCLATURE

(FIGURE 17–2) which indicates static timing in degrees Before Top Dead Center (BTDC). Static timing is not the same for all engine models. **Refer to Test 4 in Section 19 of this manual.**

17.3.2 Engine Speed

High idle is the highest engine speed at full throttle position and no load condition.

Low idle is the lowest recommended speed that engine should run at no load, thus providing adequate output for mounted accessories.

17.3.3 Intake Manifold Pressure – Boost

It is the measurement of positive pressure in the intake manifold created by the turbocharger as the result of engine exhaust flow controlled by the A/R ratio. Specific pressure normally reflects correct turbocharger wheel speed which will provide sufficient air volume for efficient fuel combustion.

Pressure Test Kit (J39257), or a manometer may be used for this test.

NOTE:

When intake manifold pressure ("Boost") does not fall within the Performance Data Guidelines, the A/R number on the turbocharger turbine housing should be confirmed. Refer to FIGURE 17–3. The A/R number is cast on the outside of the turbine housing.

Turbocharger part numbers and A/R numbers can be found in the "Performance Data Guidelines" in Section 20.

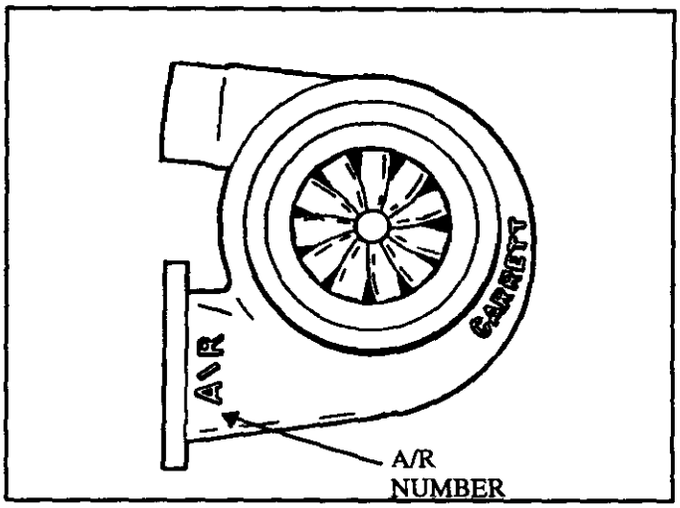

FIGURE 17–3 A/R Number Location on Turbine Housing

17.3.3.1 Definition Of A/R Number

The A/R number is Area "A" **(FIGURE 17–4)** divided by "R" – the distance from the center of the turbine wheel to the centroid of Area "A" – which will determine the flow of the gas for a given turbine wheel. If "A" is increased, the turbine wheel will slow down. If "A" is decreased, the turbine wheel will increase in speed and boost pressure will increase giving false readings and premature turbocharger failure can be expected. The specified A/R turbine housing must not be changed to ensure maximum engine life and performance.

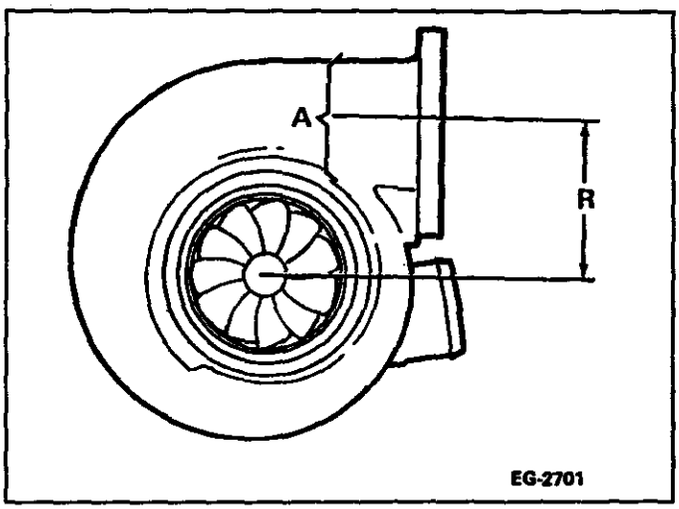

FIGURE 17–4 A/R Definition Location

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ENGINE TEST NOMENCLATURE

17.3.4 Exhaust Back Pressure

Exhaust back pressure is the measurement of the restriction introduced by the exhaust piping. Excessive restriction will create high back pressure, a rise in engine temperature, shorten valve life and lower horsepower. Pressure Test Kit (J39257), or a manometer can be used for this test to measure exhaust backpressure in inches of water.

17.3.5 Smoke Level Test

The smoke level test is performed to determine the acceptability of exhaust smoke level as determined by the Environmental Protection Agency (EPA). The test is performed by using a diesel smoke opacity meter and/or a smoke sampling kit. The smoke sample filter disks used with the Bosch kit are evaluated by using the Robert Bosch Evaluating Instrument (Bosch Part No. 0 681 169 039) or visually comparing the disk to the BACHARACH OIL BURNER SMOKE SCALE. **(See NOTE).**

NOTE:

Order Bacharach Oil Burner Smoke Scale

From:

A.A. Englehardt Co.

6117 North Elston Avenue

Chicago, IL. 60646

17.3.6 Crankcase Pressure

This test measures the restricted combustion "blow–by" gas flow as designed by the crankcase breather system. It is measured in inches of water. Constant monitoring of this pressure will allow one to follow internal engine power cylinder wear.

Positive crankcase pressure is normal and is intentionally designed into the engines. Readings recorded beyond guideline tolerances signal a need to completely review engine condition.

17.3.7 Fuel Pressure

The fuel pressure test reflects the availability of sufficient quantity and resistance to flow of fuel.

The pressure is developed by the injection pump supply pump and is required to charge the injection pump's high pressure system.

17.3.8 Air Cleaner Restriction

The air cleaner restriction check measures the resistance to flow of air through the complete air intake system (air filter, piping, hosing, etc.) of engine. Excessively high resistance will result in improper air fuel ratio, high smoke level, heating and low power. The tools needed to perform this check are included in the Pressure Test Kit (J39257), or a manometer. Readings beyond the guidelines indicate dirty filters and can cause turbocharger oil seals to unseat drawing oil into the engine.

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18 ENGINE DIAGNOSTIC TOOLS

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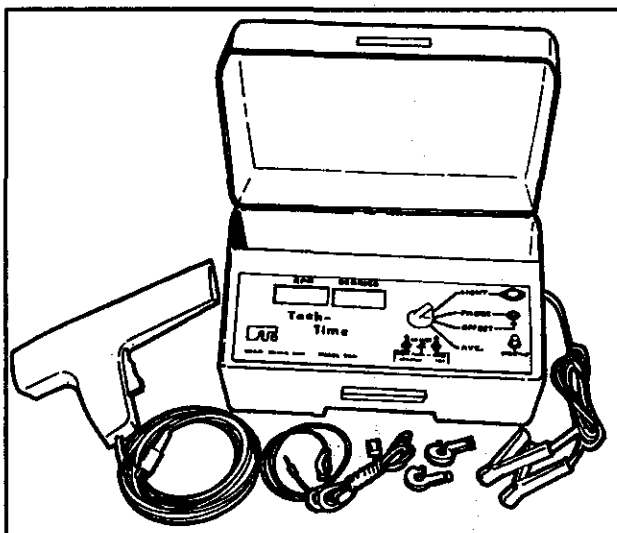
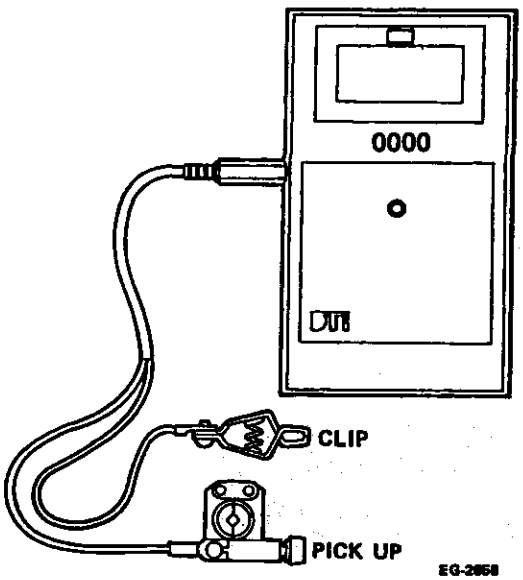
18.1 NECESSARY DIAGNOSTIC TOOLS

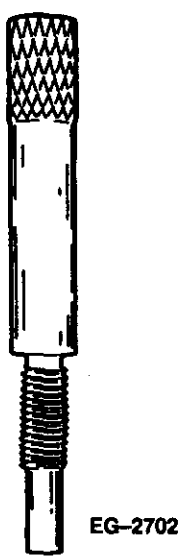
Listed and illustrated in this section are the necessary diagnostic tools required to perform accurate engine analysis.



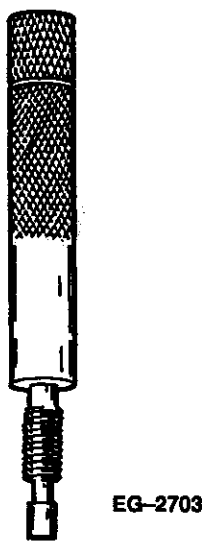
DESIGN TECHNOLOGY
TECH TIME MODEL 3354



HANDHELD ELECTRONIC TACHOMETER



TIMING PIN J41161
PURPOSE: SETS STATIC INJECTION PUMP TIMING DURING PUMP INSTALLATION



PLUNGER TIMING PIN J41162
PURPOSE: TO VERIFY INJECTION PUMP TIMING

FIGURE 18–1 Necessary Diagnostic Tools

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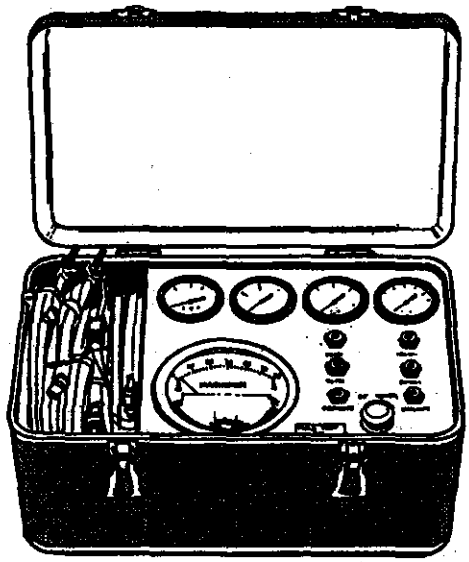
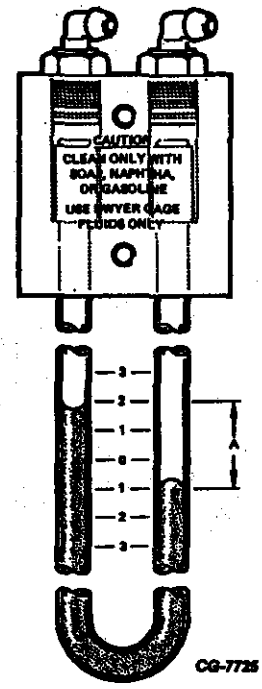
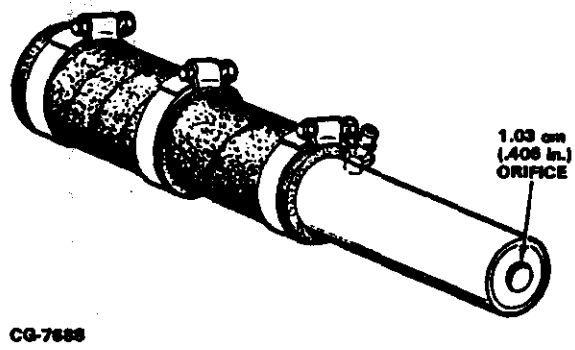
NECESSARY DIAGNOSTIC TOOLS



PRESSURE TEST KIT
MODEL D200
(J39257)



SLACK TUBE MANOMETER
DWYER NO. 1211–48



ORIFICED RESTRICTOR TOOL
J39267

FIGURE 18–2 Necessary Diagnostic Tools (continued)

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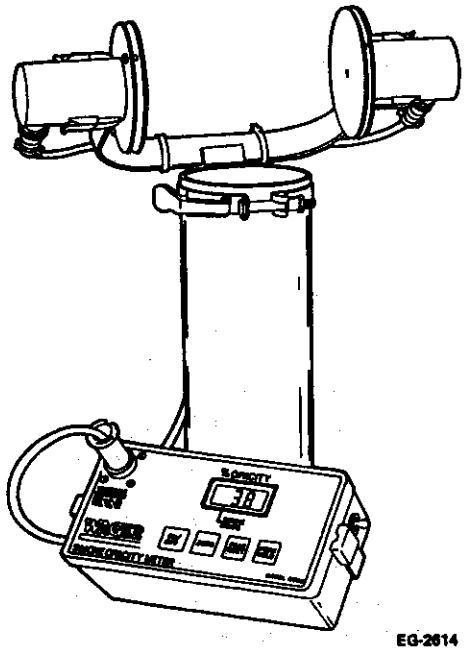
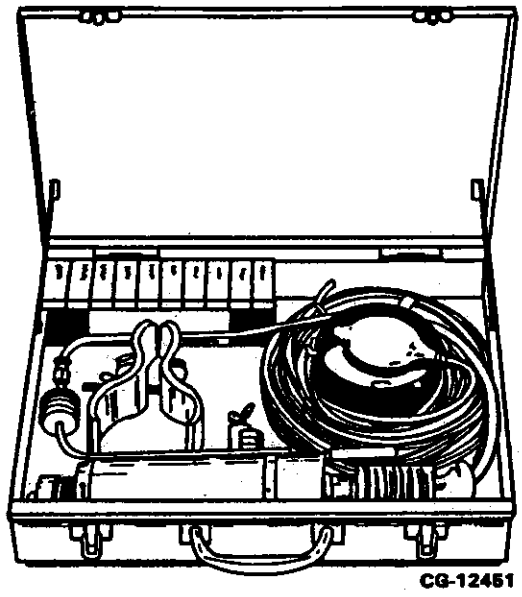
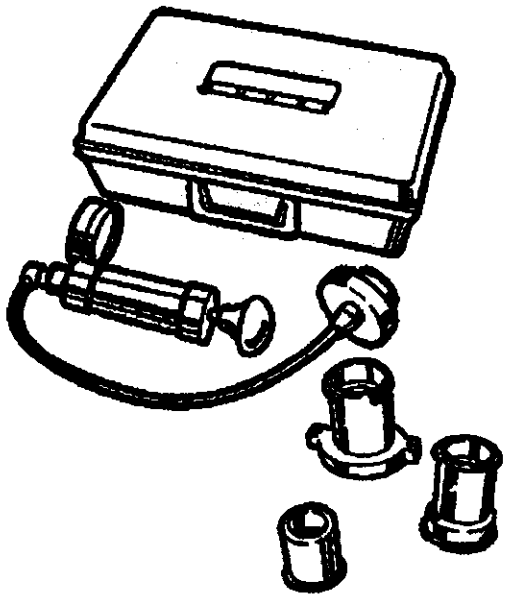
NECESSARY DIAGNOSTIC TOOLS



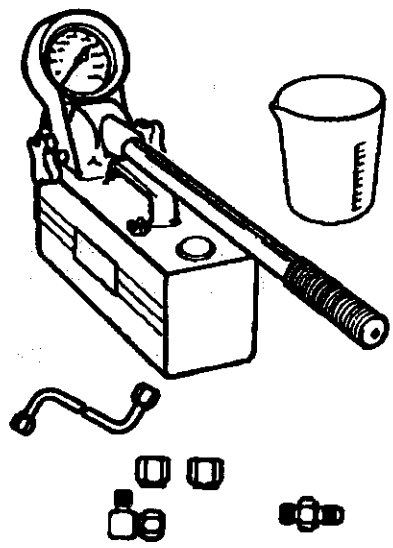
WAGER PORTABLE SMOKE METER MODEL 650A



ROBERT BOSCH SMOKE SAMPLING KIT SE–2580



COOLING SYSTEM & RADIATOR CAP TESTER



INJECTOR NOZZLE TESTER J29075–150

FIGURE 18–3 Necessary Diagnostic Tools (continued)

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18.2 DESIGN TECHNOLOGY "TECH TIME"

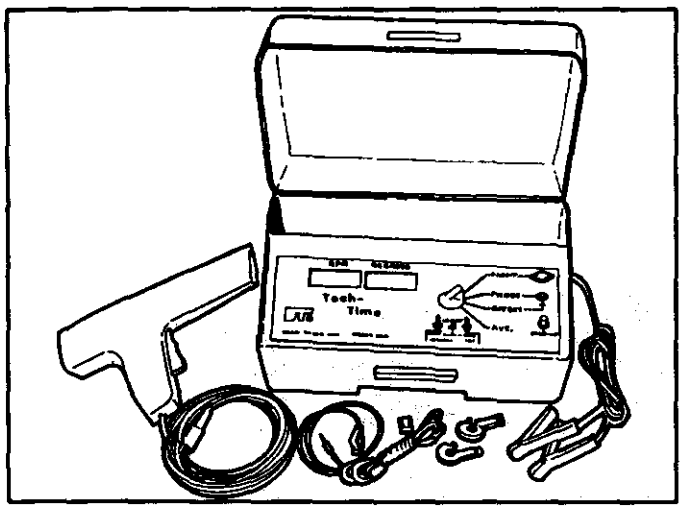

FIGURE 18–4 Design Technology "Tech Time"

The Design Technology Dynamic Timing Meter, Model 3354, (**FIGURE 18–4**) is a solid state timing meter and tachometer. It is used to accurately time diesel engines. The injection pump pulse is picked up by a transducer that clamps to the fuel line and senses the fuel surge. Crankshaft location is picked up with a magnetic probe or timing light.

NOTICE: **Only the tachometer function of the Dynamic Timing Meter Model 3354 is to be used to diagnose Series 40 engines. Dynamic timing is not measured.**

18.2.1 Transducer Installation

3. Select the appropriate size transducer.
4. Clamp on the transducer to the #1 fuel injection line at the injection pump end.
   Please observe the following:

- ❑ The transducer must be securely attached on a straight section of the fuel line at the injection pump end.
- ❑ Clean the fuel line with abrasive cloth or steel wool to remove all paint prior to affixing the transducer.
- ❑ Do not allow the transducer to contact the injection line nut.
- ❑ Do not overtighten the transducer on the fuel line. A snug fit is all that is necessary for pulse detection.
- ❑ Transducer must be dry. Wet conditions can cause erratic readings. If erratic readings are observed, remove transducer, wipe line and transducer with a clean, dry cloth and spray transducer, on all surfaces, with a water displacing substance, such as WD–40) and reclamp on the fuel line.

18.2.2 Operation

Refer to the operating instructions supplied with the timing meter/tachometer.

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18.3 HANDHELD ELECTRONIC TACHOMETER

Handheld Electronic Tachometer (**FIGURE 18–5**), is a solid state tachometer. Engine r/min is accurately measured with this unit when checking rated, low or high idle speeds. The injection pump pulse is picked up by a transducer (pickup) that clamps to the fuel line and senses the fuel surge.

Clamp on the transducer to the #1 fuel injection line at the injection pump end.

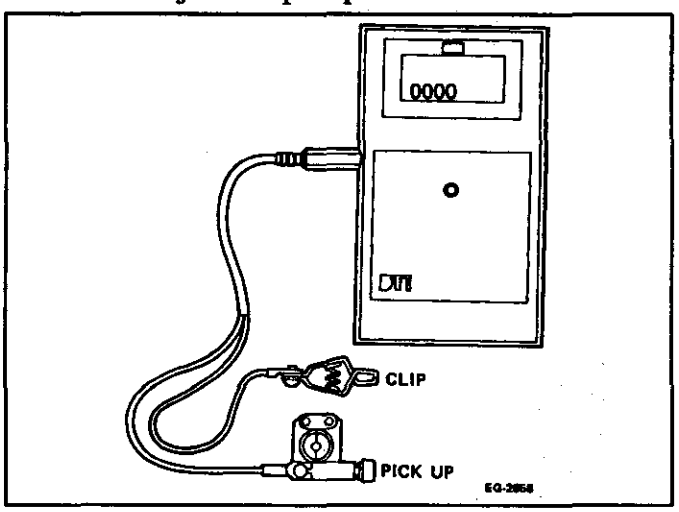

FIGURE 18–5 Handheld Electronic Tachometer

Please observe the following:

- ❑ The transducer must be securely attached on a straight section of the fuel line at the injection pump end.
- ❑ Clean the fuel line with abrasive cloth or steel wool to remove all paint prior to affixing the transducer.
- ❑ Do not allow the transducer to contact the injection line nut.
- ❑ Do not overtighten the transducer on the fuel line. A snug fit is all that is necessary for pulse detection.
- ❑ Transducer must be dry. Wet conditions can cause erratic readings. If erratic readings are observed, remove transducer, wipe line and transducer with a clean, dry cloth and spray transducer, on all surfaces, with a water displacing substance, such as WD–40) and reclamp on the fuel line.

18.3.1 Operation

Refer to the operating instructions supplied with the tachometer.

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18.4 TIMING PINS

There are two type of timing pins used as diagnostic tools: the timing pin and the plunger timing pin.

18.4.1 Timing Pin

Timing pin (J41161) (**FIGURE 18–6**) is used to set static injection pump timing if a static timing check indicates incorrect timing or the injection pump has been removed for inspection or service.

18.4.2 Plunger Timing Pin

Plunger timing pin (J41162) (**FIGURE 18–6**), is used to check and verify injection pump static timing when a performance problem exists with the engine.

NOTICE: **The plunger timing pin is to be used only to verify static injection pump timing. If injection pump is to be removed for service or to correct static timing use timing pin (J41162) (shown in FIGURE 18–6). Refer to the service section of this manual for procedure.**

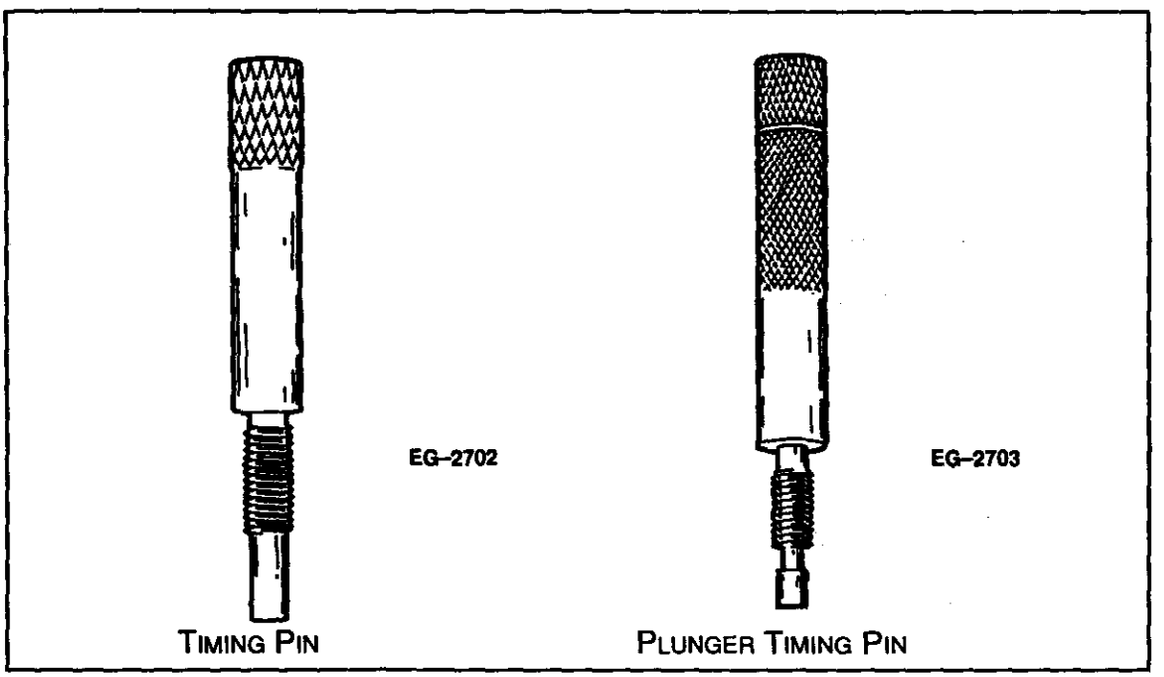

FIGURE 18–6 Timing Pin (J41161) and Plunger Timing Pin (J41162)

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18.5 BEYERS MODEL 200 PRESSURE TEST KIT

The Pressure Test Kit (**FIGURE 18–7**) can be used to measure intake manifold (Boost) pressure, fuel pressure, air cleaner restriction, fuel restriction, exhaust back pressure and crankcase pressure. It may also be used to test the accuracy of the gauges within the kit.

The 0–30 lb/in.^{2} gauge may be used to measure fuel pressure, intake manifold (Boost) pressure, or determine if boost pressure is leaking past the aneroid diaphragm.

The 0–30 in. Hg vacuum gauge (0–14.7 lb/in.^{2}), is used to measure fuel system inlet restriction.

The 0–60 inches of water (magnahelic) gauge (0–2.16 lb/in.^{2}), may be used to measure air cleaner restriction, exhaust backpressure or crankcase pressure.

CAUTION

The quick disconnects have shut–off valves in the panel connectors not in the plug. DO NOT connect or disconnect lines while under pressure. High pressure air or liquid may exist.

NOTE:

When using the magnahelic gauge, be sure to plug the test line into the proper (Pressure or Vacuum) port. Use the Pressure port to read exhaust back pressure and crankcase pressure. Use "Vacuum" port to read air cleaner restriction. In both cases, The opposite connector must be vented to the atmosphere by installing a quick connective plug in the port.

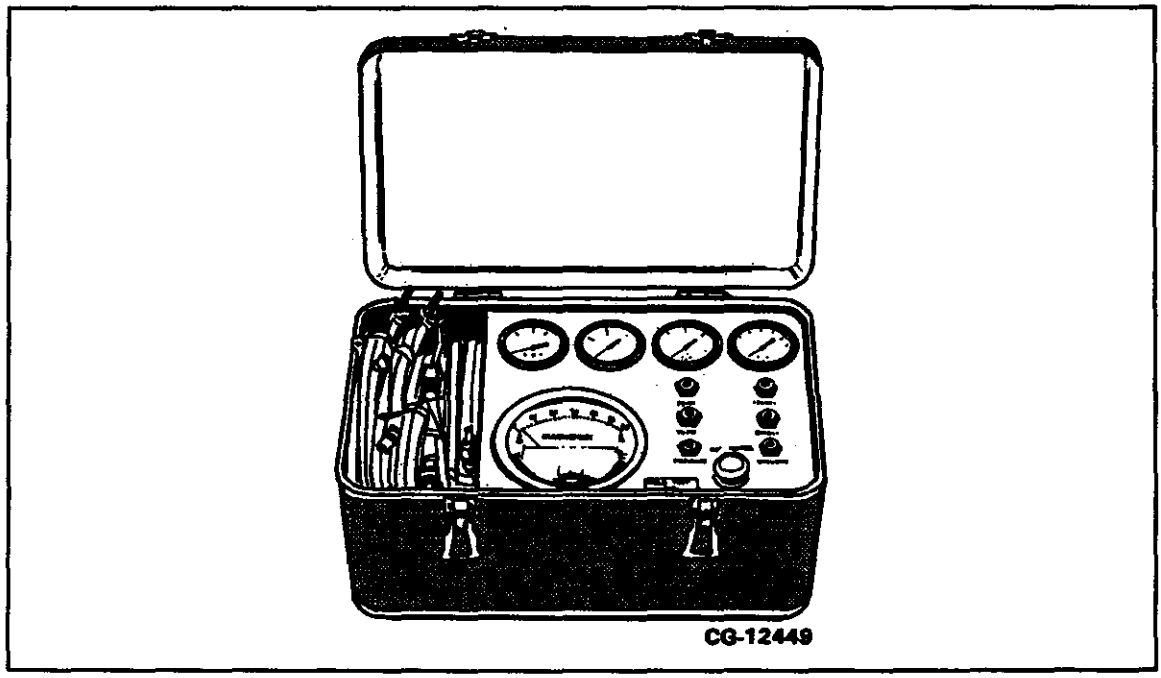

FIGURE 18–7 Pressure Test Kit Model 200 – J39257

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The 0–160 lb/in.^{2} gauge may be used to check fuel pressure.

The 0–300 lb/in.^{2} gauge is not normally used for any engine diagnostic check.

18.5.1 Maintenance and Gauge Accuracy Test

1. Remove cover of pressure test kit and inspect for damage to gauges such as broken cover glass, bent gauge needles, and for missing pressure connectors and nylon tubing. Replace damaged or missing parts so that the kit will operate when needed.
2. Remove the screws holding the gauge panel to carrying case and lift the panel from the carrying case. If any liquids are found in the tubing behind the panel, loosen the connections and blow out the liquids. Tighten all connectors as required and reassemble the gauge panel.
3. The hand operated pump is directly connected to 0–30 lb/in.^{2} gauge when the kit is received. If a gauge accuracy test is desired, proceed as described under "Calibrating The Pressure Kit using the Dwyer Slack Tube Manometer", in this section.

18.5.2 Operating Instructions

Connect tubes between the test ports on the panel and the test points shown in Section 19.

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18.6 DWYER SLACK TUBE MANOMETER

The manometer (**FIGURE 18–8**) is a "U" shaped tube with a scale mounted between the legs of the "U". Where the portability of the Model 200 Pressure Test Kit is not required, this manometer can be used to measure either low pressure or vacuum and may be filled with water.

Order from: Dwyer Instruments, Inc.
P.O. Box 373
Michigan City, Indiana 46360
Phone: (219) 872–9141

18.6.1 Filling

The manometer may be filled with water, when checking very low pressures.

When filling with water, use only good drinking water without additives except for some colored water vegetable dye which enables the tester to read the scale easier. With both legs of the manometer open to the atmosphere, fill the tube until the top of the fluid column is near the zero mark on the scale. Shake the tube to eliminate any air bubbles.

NOTICE: **Never use an antifreeze solution, soda pop, tonic, etc. The increase in density causes false readings.**

18.6.2 Installing and Reading

1. Support the manometer in a vertical position. Be sure the fluid is at the zero mark on the scale.
2. Connect one leg of the manometer to the source of the pressure or vacuum. Be sure the other leg is open to atmosphere.

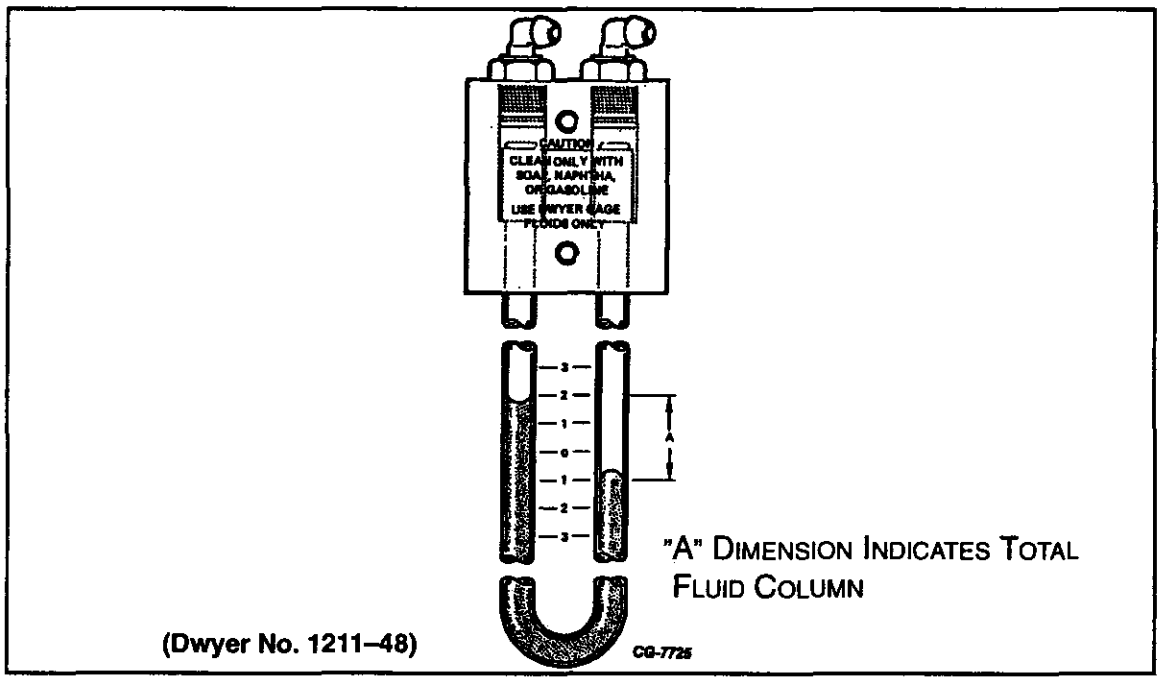

FIGURE 18–8 Slack Tube Manometer

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3. Start the engine and when the engine is in the proper operating condition as specified in Performance Data Guideline pages, observe the manometer.
4. After about two minutes, record the average position the fluid level is above and below the zero mark. Add the two figures together. The sum of the two is the total column of fluid.

NOTE:

At times both columns of the manometer will not travel the same distance. This is of no concern to the tester as long as the leg not connected to the pressure or vacuum source is open to the atmosphere.

5. If it is necessary to convert from the column of fluid to lb/in.^{2} from kPa, refer to the "Metric Conversion Factor Chart" in Appendix H.

18.6.3 Cleaning

Wash the tube thoroughly with a little pure soap and water. Avoid liquid soaps and solvents.

Wager Portable Smoke Meter Model 650A

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18.7 WAGER PORTABLE SMOKE METER – MODEL 650A

The Wager portable smoke opacity meter Model 650A, **FIGURE 18–9**, detects and measures the percent opacity of smoke at the exhaust stack. It consists of a control unit, light sensor head with adaptors and a long connecting cable which connects the light sensor head to the control unit. The unit operates from power supplied by six ni–cad C batteries.

The opacity of smoke is measured by passing exhaust gas between a light source and a sensor which are mounted on special adapters which attach to the exhaust stack. Opacity is read directly in percent. The opacity reading on this meter represents the amount of light being blocked by the smoke as it passes through the sensor head.

The portability of this unit allows smoke measurements to be taken on the road. This enables the technician to quickly diagnose an engine performance problem.

18.7.1 Installation and Operation

The smoke opacity meter sensor head must be attached to the vehicle's exhaust pipe. Use the appropriate adaptor which fits the vehicle's exhaust stack.

CAUTION

The exhaust stack may be hot. Wear protective gloves while installing the sensor head to the exhaust stack.

Place the control unit in a convenient location and connect the cable to the sensor head and control unit. Refer to the manufacturer's calibration and operating instructions to properly operate and measure smoke opacity levels.

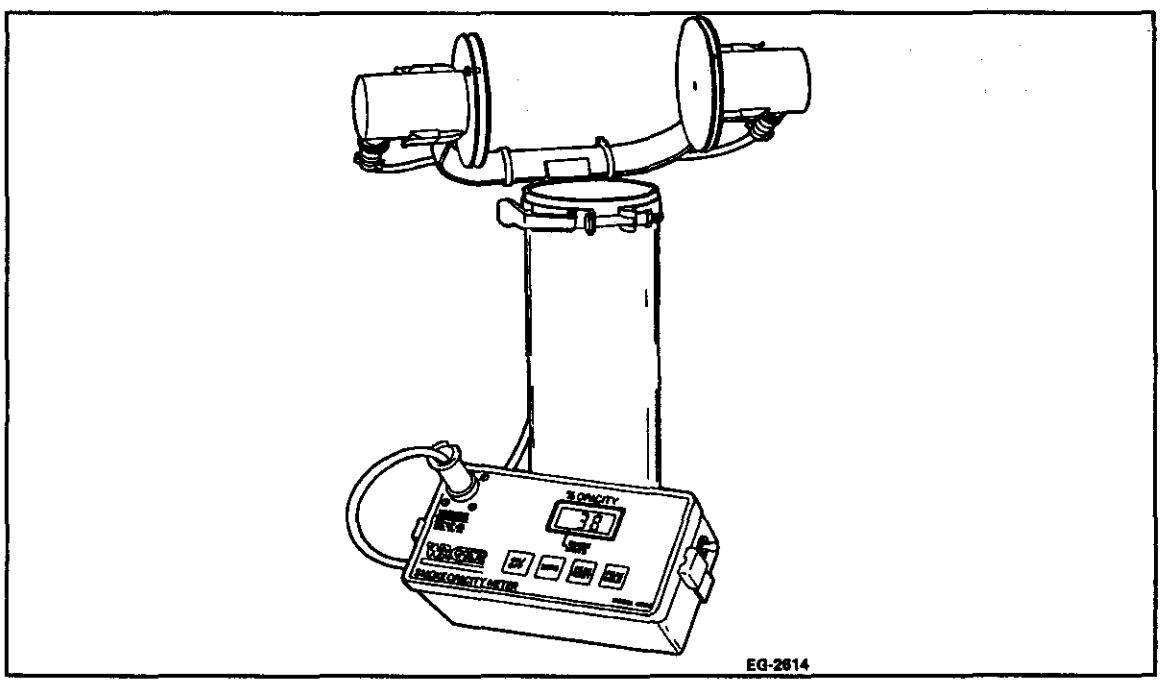

FIGURE 18–9 Wager Portable Smoke Opacity Meter Model 650A

18.8 ROBERT BOSCH SMOKE SAMPLING KIT (SE–2580)

The smoke sampling kit (**FIGURE 18–10**) is used for reading smoke density at the exhaust stack at rated load and speed only to determine acceptability of smoke emission.

18.8.1 Operation

In the smoke meter, a sampling pump draws off a certain amount of exhaust gas from the exhaust pipe of the respective engine and then sucks it through a filter paper disk. The filter paper disk, in turn, darkens during this process and thus gives the measure of the soot content of the exhaust gases.

Refer to Section 19 for operation and maintenance instructions

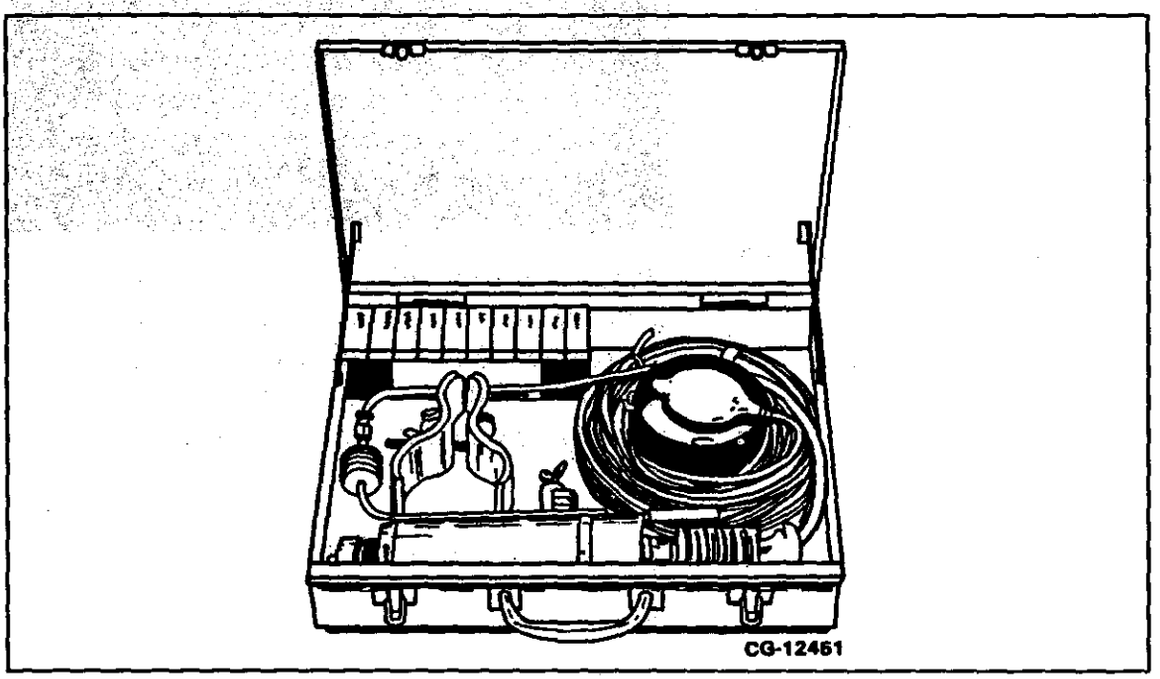

FIGURE 18–10 Smoke Sampling Kit

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18.9 CRANKCASE PRESSURE ORIFICED RESTRICTOR

The restrictor (**FIGURE 18–11**) is used to measure combustion gas flow out of the engine breather and is used with the Model 200 pressure test kit.

NOTICE: **Pressure readings obtained with this restrictor must be used as the main source of engine condition. Oil consumption trend data must also be used if the pressure readings are beyond the specified limits. Neither changes in oil consumption trends nor crankcase diagnostic pressure trends can establish a specific component problem, but are only indicators that some problem exists.**

18.9.1 Operation

Refer to Crankcase Pressure Test in Section 19.

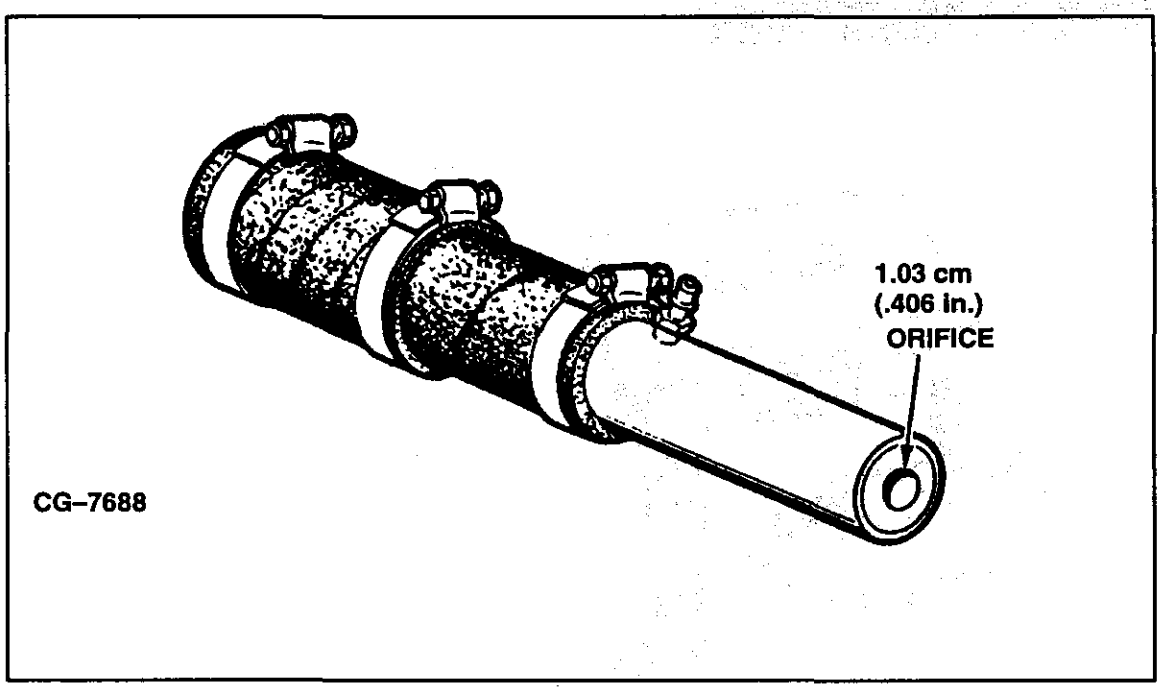

FIGURE 18–11 Orificed Restrictor Tool (J39267)

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18.10 COOLING SYSTEM AND RADIATOR CAP TESTER

Cooling system tester (**FIGURE 18–12**) is used to check pressure caps and cooling systems on standard automobiles and trucks.

18.10.1 Operation

CAUTION

Allow engine to cool before testing the cooling system or radiator cap.

Refer to the operating instructions supplied with the tester.

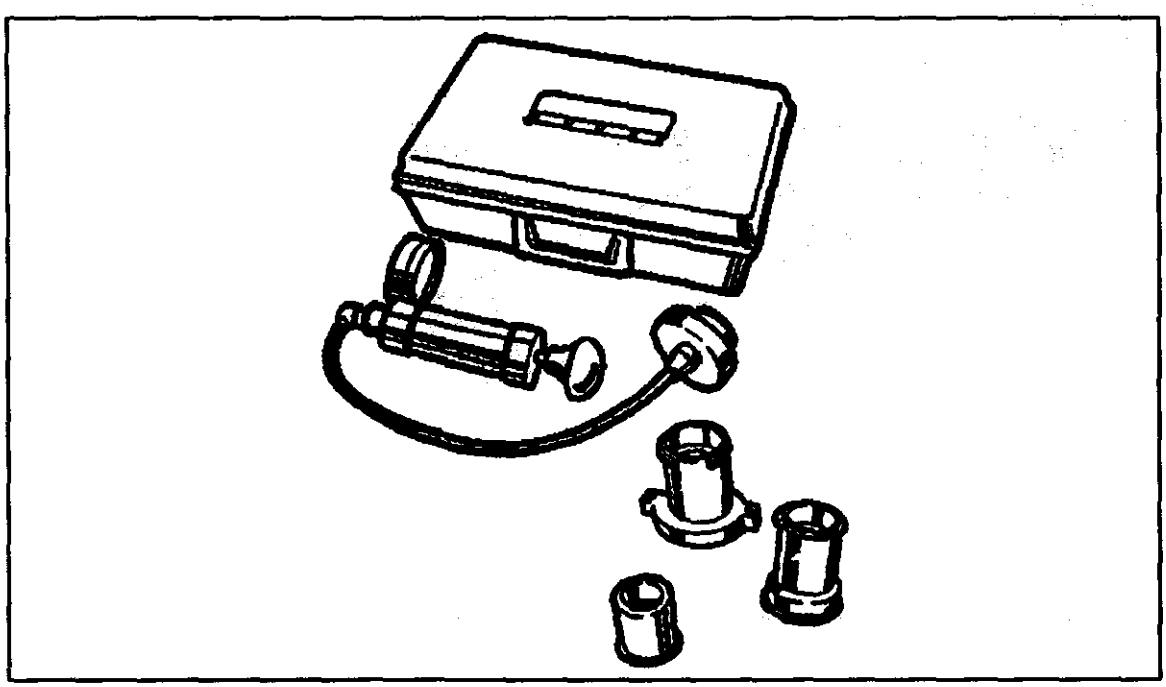

FIGURE 18–12 Cooling System Tester

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18.11 INJECTOR NOZZLE TESTER

This portable tester (**FIGURE 18–13**) is used to test injector nozzle opening pressure, spray pattern, chatter, leakage and return fuel flow.

18.11.1 Operation

Refer to Section 19 for "Testing Injection Nozzles".

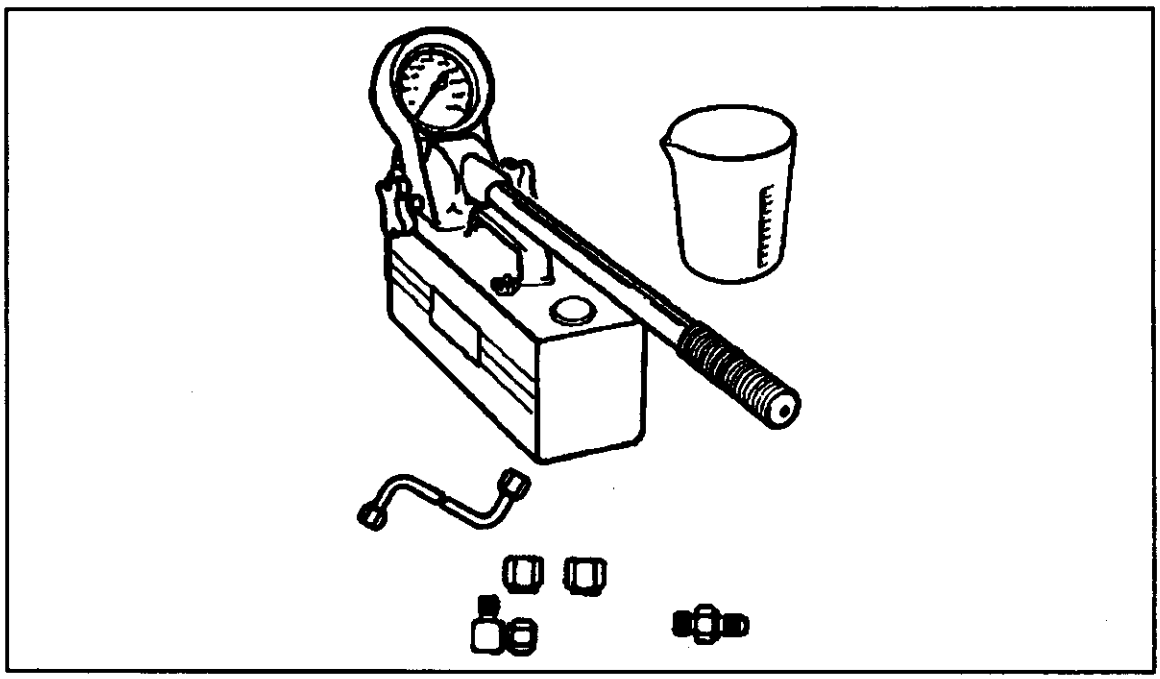

FIGURE 18–13 Injector Nozzle Tester – (J29075–150)

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19 ENGINE DIAGNOSTIC TEST PROCEDURES

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19.1 DIAGNOSTIC ANALYSIS GUIDE FOR THE SERIES 40

Use the Diagnostic Analysis Guide 7SE416, **FIGURE 19–1,** to check the engine. If data obtained is not within the guidelines shown on the "Performance Data Guideline" sheets located in Section 20, the procedures in "Diagnostic Analysis" must be followed to determine the problem.

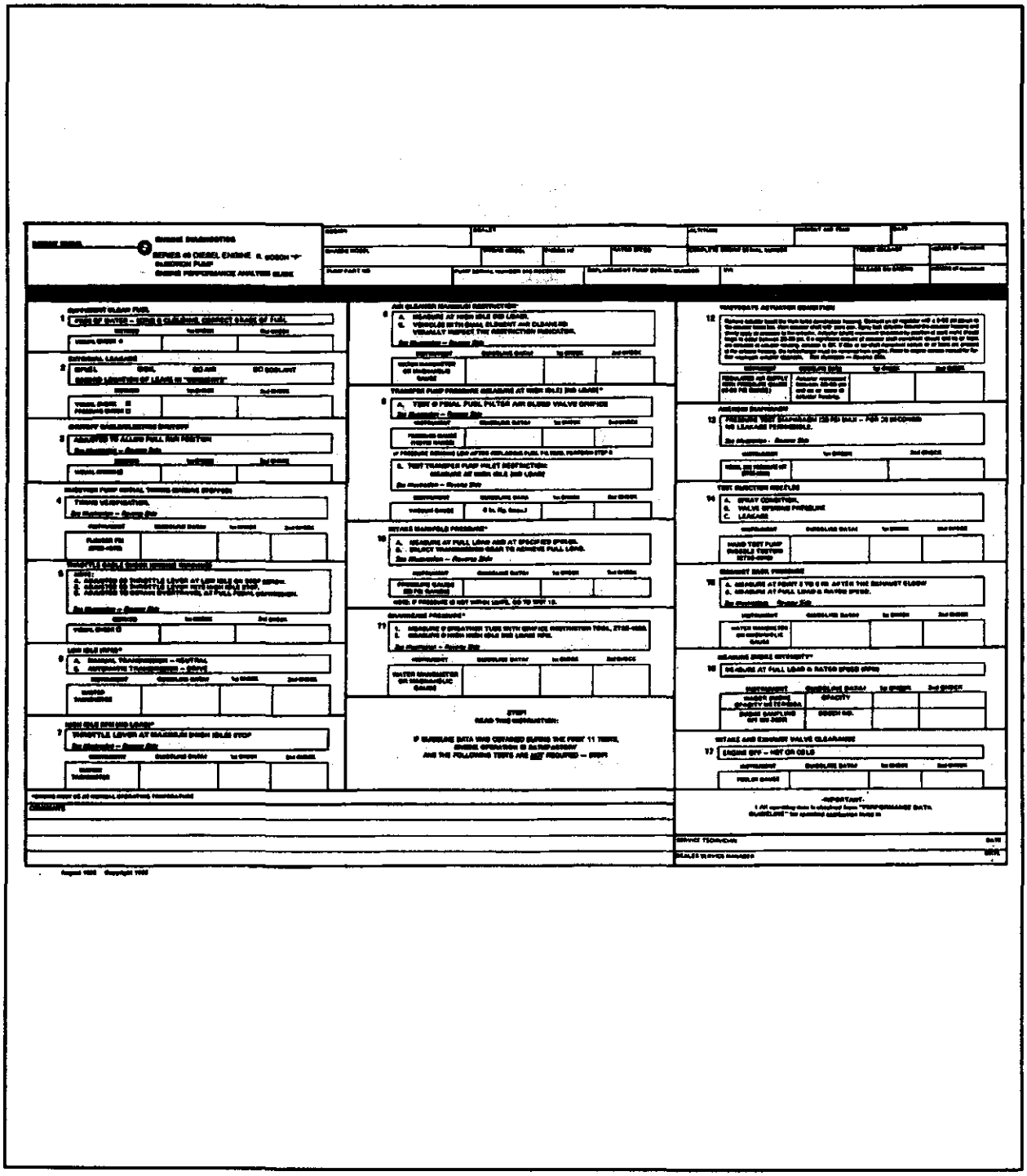

FIGURE 19–1 Diagnostic Analysis Guide (With Robert Bosch "P" Fuel Injection Pump) – Side 1

Diagnostic Analysis Guide For The Series 40 Diesel Engines

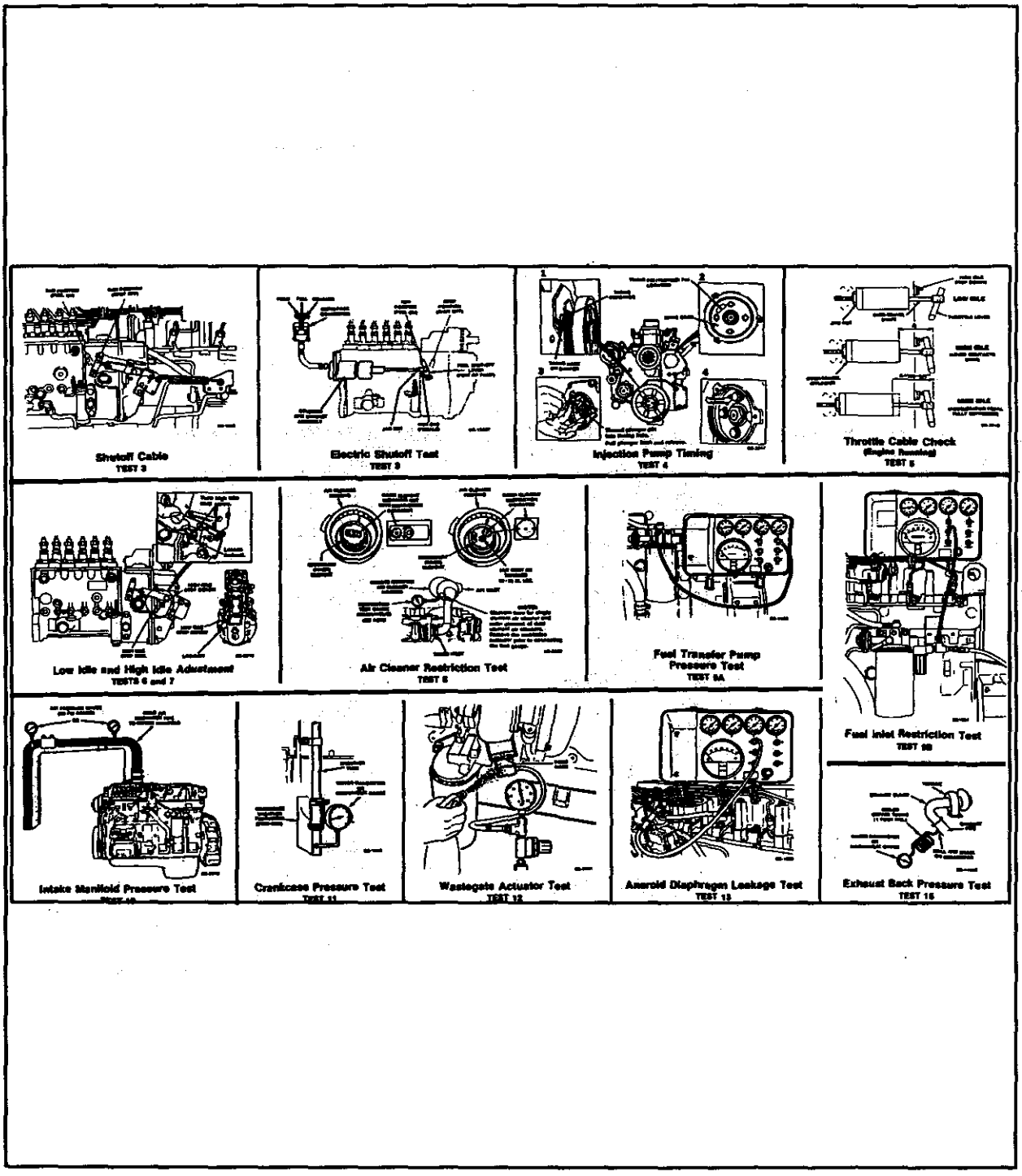

FIGURE 19–2 Diagnostic Analysis Guide (With Robert Bosch "P" Fuel Injection Pump) – Side 2

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ENGINE DIAGNOSTICS

SERIES 40 DIESEL ENGINE

ENGINE PERFORMANCE ANALYSIS GUIDE

REGION	DEALER			ALTITUDE	AMBIENT AIR TEMP.	DATE
CHASSIS MODEL	ENGINE MODEL	ENGINE HP	RATED SPEED	COMPLETE ENGINE SERIAL NUMBER	TRUCK MILEAGE	HOURS (If equipped)
PUMP PART NO.	PUMP SERIAL NUMBER (AS RECEIVED)	REPLACEMENT PUMP SERIAL NUMBER		VIN	MILEAGE ON ENGINE	HOURS (If equipped)

FUEL

– ICING & CLOUDING, CORRECT GRADE OF FUEL

IOD	1st CHECK	2nd CHECK

3E

☐ OIL ☐ AIR ☐ COOLANT

ON OF LEAKS IN "COMMENTS"

IOD	1st CHECK	2nd CHECK

LECTRIC SHUTOFF

LOW FULL RUN POSITION

Reverse Side

IOD	1st CHECK	2nd CHECK

TIAL TIMING (ENGINE STOPPED)

ATION.

Reverse Side

GUIDELINE DATA†	1st CHECK	2nd CHECK

CHECK (ENGINE RUNNING)

THROTTLE LEVER AT LOW IDLE ON STOP SCREW.
THROTTLE LEVER HITS HIGH IDLE STOP.
OBTAIN OVERTRAVEL AT FULL PEDAL DEPRESSION.

Reverse Side

IOD	1st CHECK	2nd CHECK

ANSMISSION – NEUTRAL
TRANSMISSION – DRIVE

GUIDELINE DATA†	1st CHECK	2nd CHECK

LOAD)*

ER AT MAXIMUM (HIGH IDLE) STOP

Reverse Side

GUIDELINE DATA†	1st CHECK	2nd CHECK

RATING TEMPERATURE

AIR CLEANER MAXIMUM RESTRICTION*

8
A. MEASURE AT HIGH IDLE (NO LOAD).
B. VEHICLES WITH DUAL ELEMENT AIR CLEANERS:
VISUALLY INSPECT THE RESTRICTION INDICATOR.
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

TRANSFER PUMP PRESSURE (MEASURE AT HIGH IDLE) (NO LOAD)*

9
A. TEST @ FINAL FUEL FILTER AIR BLEED VALVE ORIFICE
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
PRESSURE GAUGE (160 PSI RANGE)			

IF PRESSURE REMAINS LOW AFTER REPLACING FUEL FILTERS, PERFORM STEP B

B. TEST TRANSFER PUMP INLET RESTRICTION:
MEASURE AT HIGH IDLE (NO LOAD).
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA	1st CHECK	2nd CHECK
VACUUM GAUGE	6 In. Hg. (max.)		

INTAKE MANIFOLD PRESSURE*

10
A. MEASURE AT FULL LOAD AND AT SPECIFIED SPEEDS.
B. SELECT TRANSMISSION GEAR TO ACHIEVE FULL LOAD.
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
PRESSURE GAUGE (30 PSI RANGE)			

CRANKCASE PRESSURE*

11
1. MEASURE @ BREATHER TUBE WITH ORIFICE RESTRICTOR TOOL
2. MEASURE @ HIGH HIGH IDLE (NO LOAD) RPM.
See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

STOP!
READ THIS INSTRUCTION:

IF GUIDELINE DATA WAS OBTAINED DURING THE FIRST 11 TESTS,
ENGINE OPERATION IS SATISFACTORY
AND THE FOLLOWING TESTS ARE NOT REQUIRED – STOP!

WASTEGATE ACTUATOR CONDITION

12
Remove actuator boost line from turbo compressor housing. Connect an air regulator with a 0-60 psi gauge to the actuator boost line. Mark actuator shaft with paint pen. Spray leak detector around the actuator housing and slowly apply air pressure to the actuator. Actuator (shaft) movement (indicated by position of paint mark) should begin to occur between 28-30 psi. If a significant amount of actuator shaft movement occurs and no air leaks are detected at actuator housing, actuator is OK. If little or no shaft movement occurs or air leaks are present at the actuator housing, the turbocharger must be removed from engine. Refer to engine service manual for further wastegate actuator diagnosis. *See Illustration – Reverse Side.*

INSTRUMENT	GUIDELINE DATA	1st CHECK	2nd CHECK
REGULATED AIR SUPPLY WITH PRESSURE GAUGE (0-60 PSI GUAGE)	Actuator movement between 28-30 psi and no air leaks at actuator housing.		

AMEROID DIAPHRAGM

13
PRESSURE TEST DIAPHRAGM (20 PSI MAX – FOR 30 SECONDS)
NO LEAKAGE PERMISSIBLE.
See Illustration – Reverse Side

INSTRUMENT	1st CHECK	2nd CHECK
MODEL 200 PRESSURE KIT		

TEST INJECTION NOZZLES

14
A. SPRAY CONDITION.
B. VALVE OPENING PRESSURE
C. LEAKAGE

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
HAND TEST PUMP (NOZZLE TESTER)			

EXHAUST BACK PRESSURE

15
A. MEASURE AT POINT 3 TO 6 IN. AFTER THE EXHAUST ELBOW
B. MEASURE AT FULL LOAD & RATED SPEED.
See Illustrations – Reverse Side

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

MEASURE SMOKE INTENSITY*

16
MEASURE AT FULL LOAD & RATED SPEED (RPM)

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
WAGER SMOKE OPACITY METER 950A	OPACITY		
SMOKE SAMPLING KIT	BOSCH NO.		

INTAKE AND EXHAUST VALVE CLEARANCE

17
ENGINE OFF – HOT OR COLD

INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
FEELER GAUGE			

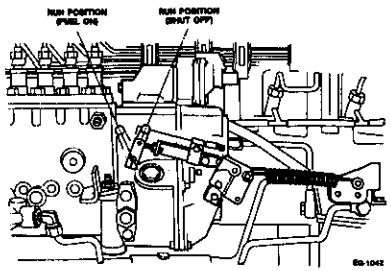
-IMPORTANT-

All operating data is obtained from "Performance Data Guideline" for specified application listed in *The Series 40 Service and Diagnostic Manual, 6SE44*

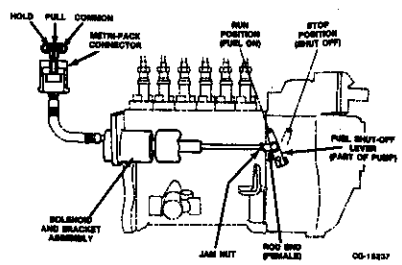
SERVICE TECHNICIAN DATE

DEALER SERVICE MANAGER DATE

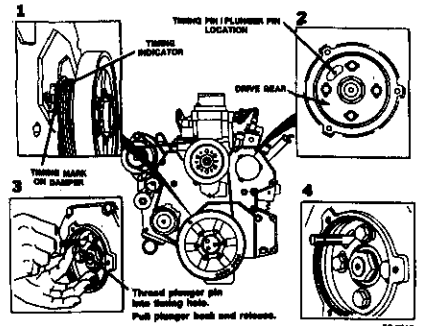
al notice. (Rev. 10/93) 7SE416 © 1993 DETROIT DIESEL CORPORATION



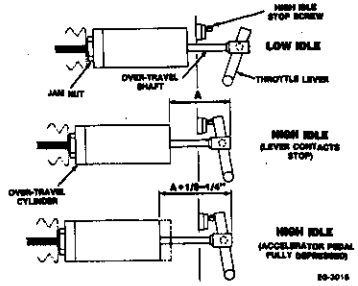
Shutoff Cable
TEST 3



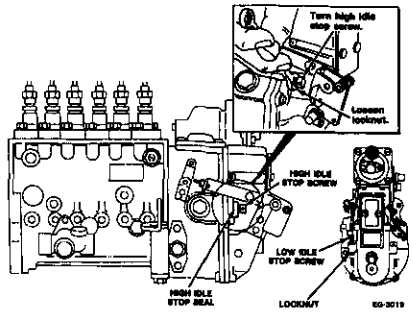
Electric Shutoff Test
TEST 3



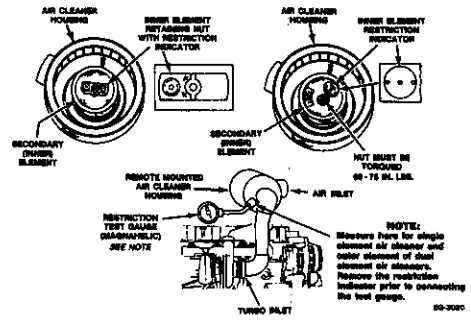
Injection Pump Timing
TEST 4



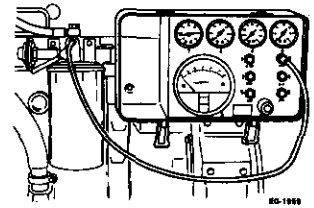
Throttle Cable Check
(Engine Running)
TEST 5



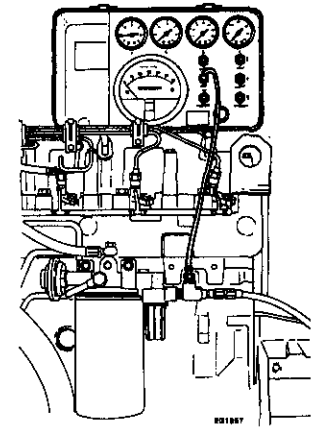
Low Idle and High Idle Adustment
TESTS 6 and 7



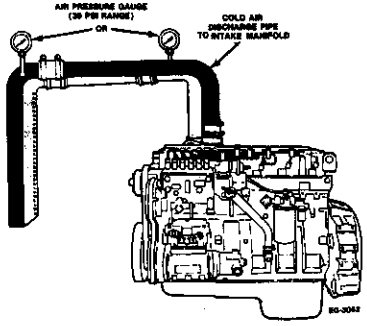
Air Cleaner Restriction Test
TEST 8



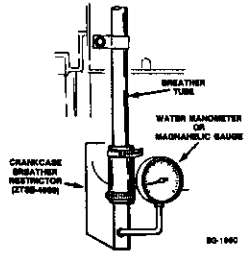
Fuel Transfer Pump Pressure Test
TEST 9A



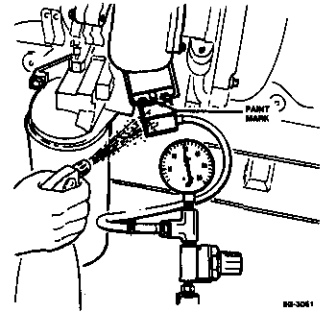
Fuel Inlet Restriction Test
TEST 9B



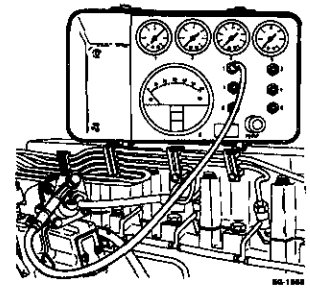
Intake Manifold Pressure Test
TEST 10



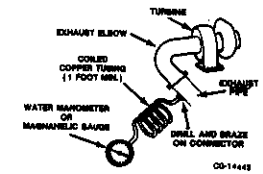
Crankcase Pressure Test
TEST 11



Wastegate Actuator Test
TEST 12



Aneroid Diaphragm Leakage Test
TEST 13



Exhaust Back Pressure Test
TEST 15

19.2 SUFFICIENT CLEAN FUEL – TEST 1

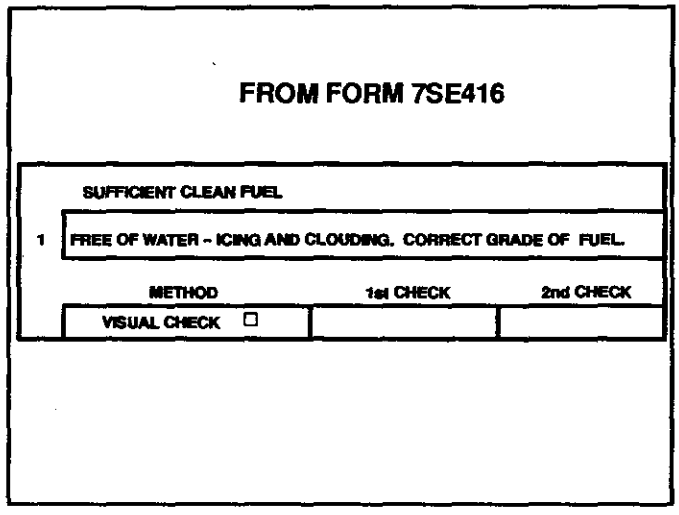


FIGURE 19–3 Sufficient Clean Fuel Check

If fuel is satisfactory, enter OK in **1st CHECK** box. Drain water or remove foreign substances as required. Record any corrective action taken in the comments section of the form.

19.2.1 Fuel Quality

Fuel must be of proper grade, clean, undiluted and free of air.

1. Check for air in fuel: Check for leaks in the supply line from the tank to the fuel pump. If in doubt, connect a piece of clear plastic tubing from the filter to the injection pump inlet. Run engine and watch for air bubbles - THERE SHOULD BE NO AIR BUBBLES.
2. Check for quality: Bypass the fuel system. Run the engine with a can of fuel known to be of good quality. Observe engine performance. If engine performance is improved with the use of the sample fuel, clean the system and refill with proper, clean fuel.

NOTE:

Cold weather can cause fuel waxing of certain grades of diesel fuel which result in fuel filter plugging.

For fuel specifications, refer to the Series 40 Operators Manual.

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19.3 EXTERNAL LEAKAGE – TEST 2

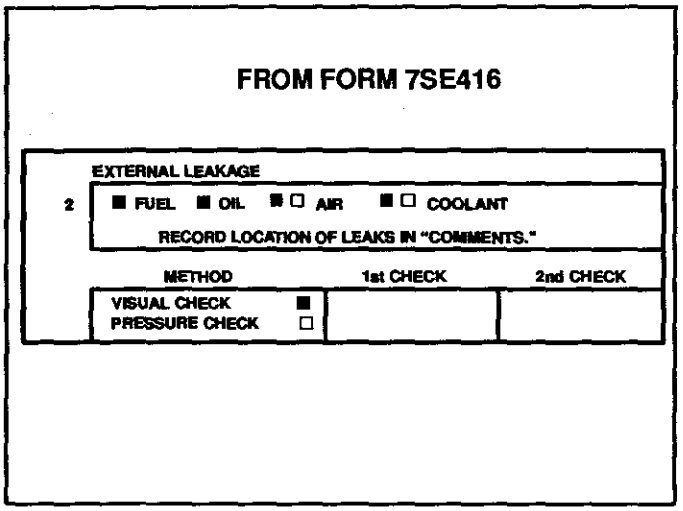

FIGURE 19–4 External Leakage Check

Inspect for fuel, oil, air or coolant leaks. If no leaks are found, enter OK in **1st CHECK** box. (**FIGURE 19–4**) Upon visual inspection, check all hoses and look for water stains, oil stains and wetness at the water pump. Record the location of leaks in the comments section.

Leakage can be the reason for complaints of poor fuel economy, or high oil consumption. A leak in the air intake system can shorten engine life, especially under dusty conditions. A coolant leak can result in a complaint of engine overheating.

If coolant and air leaks are observed, but the source not readily identified, the service technician may utilize the following test procedures to pin point the coolant or air leak.

19.3.1 Engine Coolant Leakage Test

Too often attempts to correct complaints of external and/or internal water leakage reflects an arbitrary replacement of oil to water coolers and/or a complete engine teardown for a visual inspection. Components such as cylinder heads, coolers, etc., are either sent out for inspection and/or replaced as the result of a guess. **This is not a recommended approach and in most cases leaves much doubt if all leakage areas have been identified.**

The procedure described in Section 16, subsection 16.2.4, identifies the most common points of leakage and describes the step–by–step instructions required to properly test for leakage.

19.3.2 Air Induction System Pressure Test

The most common cause of engine failure is dirt. Even though an air cleaner element itself is properly serviced there are other areas in the induction system which must be maintained. The importance of pressure testing the air induction system cannot be emphasized enough with present–day high speed diesel engines. An air induction leak on the suction side, no matter how small, can cause an engine failure and must not be tolerated.

Test for leakage in the air induction system using a manually regulated compressed air supply, 0–15 lb/in.^{2} (0–103 kPa) pressure test gauge.

19.3.2.1 Test Procedure

1. Mask off the outer diameter of air cleaner element air inlet with duct tape and plug air cleaner canister drain.

2. Remove the air cleaner restriction indicator or tubing at the air cleaner. Install a plug to seal opening.

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EXTERNAL LEAKAGE

3. Locate tap on cold air discharge pipe which may contain a plug or a line which supplies ether to the intake system. Remove the plug or line and connect a manually regulated air supply with pressure gauge to the tap opening.
4. Apply 5–8 lb/in.^{2} of air pressure with regulator to pressurize the air induction system. A constant supply of air is needed to compensate for the air loss through opened intake valves.
5. Coat the following areas with the soap solution and check for leaks. Leaks will cause air bubbles to form: **(FIGURE 19–5)**
   a. Air cleaner body surface around the outlet pipe.
   b. Air cleaner outlet pipe to air cleaner body junction.
   c. All clamped hose and gasket connections between air cleaner outlet and intake manifold/valve cover. This includes connections at turbocharger.
   d. Surface of all air induction piping and hoses between air cleaner and intake manifold/valve cover.
   e. When applicable, the air compressor air inlet piping from the air cleaner tube to and including the fitting and the gasket.
   f. Piping to the air charge cooler.
6. No leakage is permitted between air cleaner and turbocharger (suction side). If leakage at the joints is detected, tighten hose clamps. If leakage still persists, remove the parts to determine the cause. Replace parts as necessary using the latest clamps and torques specified. Retest the corrected area.

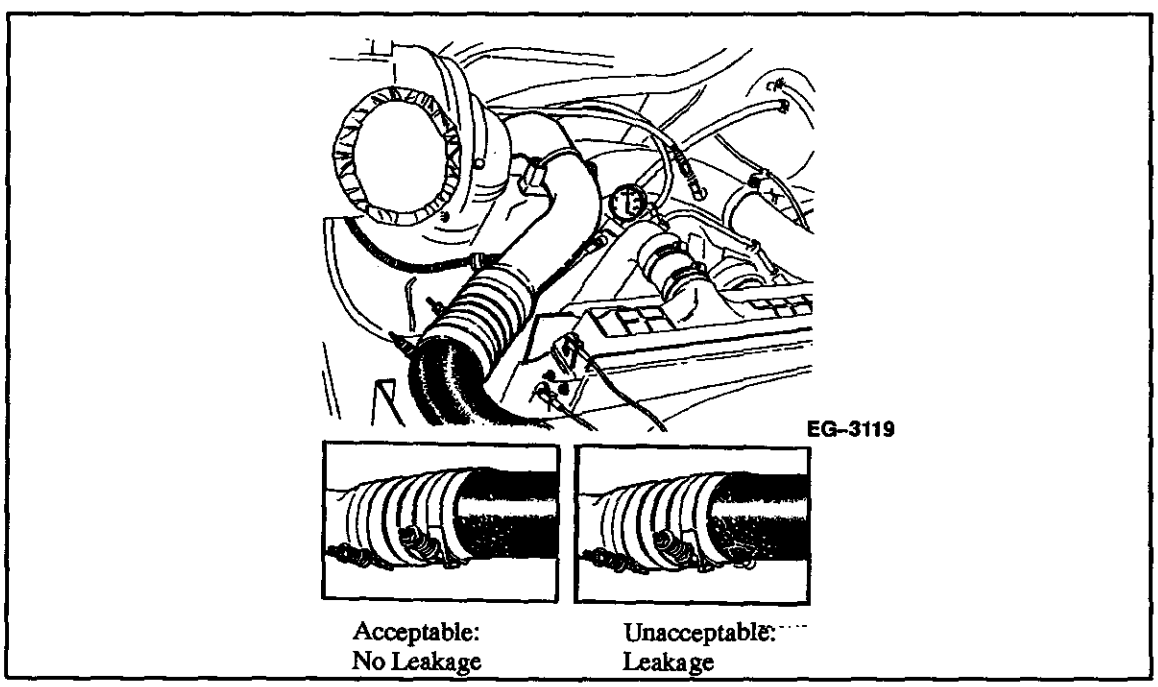

FIGURE 19–5 Air Induction System Pressure Test

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EXTERNAL LEAKAGE

NOTE:

Any leaks found in the air induction system could have allowed dirt to enter the engine. Dirt entering engine can cause piston rings to wear abnormally or break (which causes high oil consumption), excessive blue smoke, turbocharger compressor wheel pitting and erosion. If any leaks are found in the air intake system, you can check the internal condition of the engine by running a crankcase pressure check.

19.3.2.2 Visual Inspection

Visually inspect the following:

1. Inspect air cleaner housing externally for damage or distortion which could allow unfiltered air to enter the engine.
2. Inspect air cleaner housing internally for end seal movement indicated by polishing where end seal contacts the air cleaner housing. End seal movement indicates dirt may have passed the air cleaner element and entered the engine.
3. Inspect air cleaner element for holes, damaged seals, element sooting, end cap denting because of over tightening or damage during servicing.
4. Inspect hoses and clamps for tightness and positioning over sealing beads.
5. Inspect the chassis mounted air charge cooler and piping.

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19.4 SHUTOFF CABLE/ELECTRIC SHUTOFF – TEST 3

FROM FORM 7SE416

	SHUTOFF CABLE/ELECTRIC SHUTOFF		
3	ADJUSTED TO ALLOW FULL RUN POSITION. *See Illustration – Reverse Side*		
	METHOD	1st CHECK	2nd CHECK
	VISUAL CHECK ☐		

FIGURE 19–6 Shutoff Cable/Electric Shutoff Check

NOTE:

If the shutoff cable or electric shutoff is properly adjusted and functional, enter OK in first check block. As necessary, adjust linkage or solenoid and indicate correction in comments section.

19.4.1 Shutoff Cable (Manual Shutoff)

Visually check the shutoff cable. With the shutoff cable pulled out to stop the engine, the shutoff lever must contact the shutoff screw, as shown in **FIGURE 19–7**.

19.4.1.1 Adjustment

To ensure that the control rack is not restricted by the shutoff lever during engine operation perform the following steps to properly adjust the shutoff cable.

1. Loosen the screw which secures the shutoff cable to the shutoff lever.
2. Push the shutoff cable knob in the cab to fully seat it against the instrument panel.
3. Place the shutoff lever in the (Full Run–Fuel On Position). Move shutoff lever **1/16 in. to 1/8 in.** away from (Full Run–Fuel On Position). Secure cable to lever.

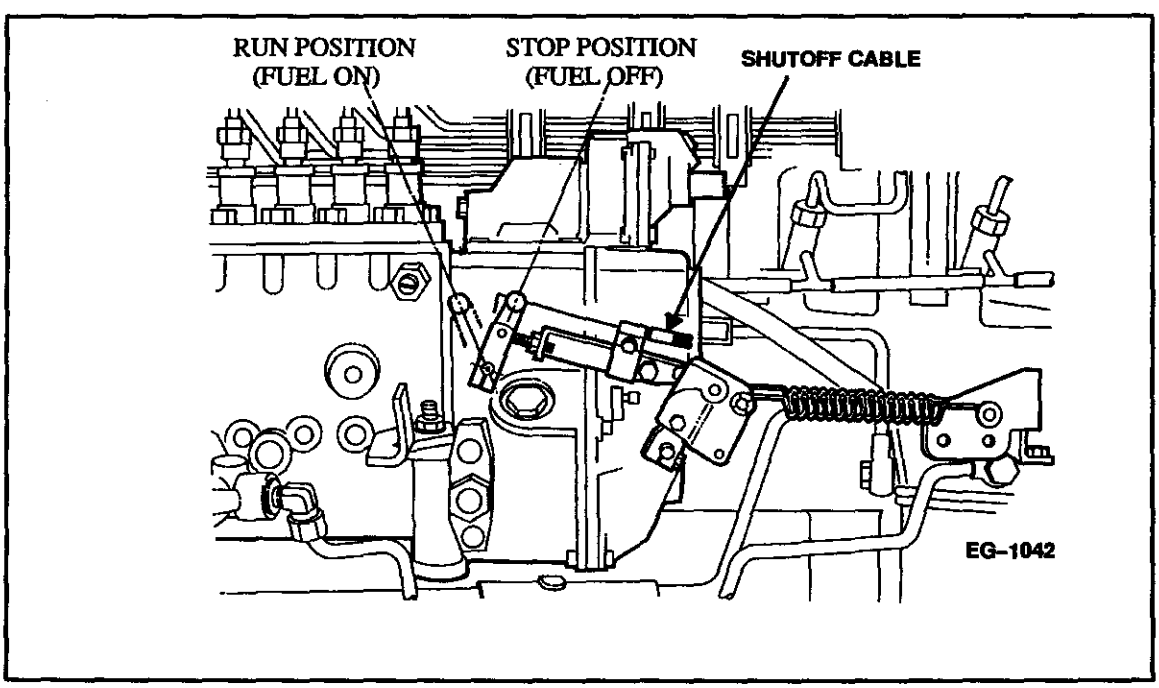

FIGURE 19–7 Shutoff Test

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SHUTOFF CABLE/ELECTRIC SHUTOFF

19.4.2 Electric Shutoff (Automatic Shut-off) 12 or 24 Volt

Problem: Engine will crank, but will not start.

SERVICE TIP

Prior to ESO Solenoid diagnostic check, verify that the proper COLD START procedure has been followed.

1. **Set the parking brake, put the transmission in neutral and depress the clutch, if applicable. DO NOT DEPRESS THE ACCELERATOR PEDAL AT THIS TIME!**
2. **Turn the keyswitch to the "START" position to engage starter/pull in E.S.O.**
3. **After the starter is engaged fully, depress the accelerator pedal to provide starting fuel quantity.**
4. **Refer to vehicle Operator's Manual for additional starting instructions.**
5. **If the engine still DOES NOT START begin ESO diagnostic routine.**

NOTICE: **Place the transmission in neutral with the parking brake on.**

Verify the electric shutoff is inoperable as follows:

1. Visually observe the shutoff lever **(FIGURE 19-8)**
2. Turn the key switch to the "Start" position (for vehicles without pushbutton start).

For vehicles with pushbutton start:

1. Turn key switch to the "On" position .
2. Push the start pushbutton. The shutoff lever should rotate counterclockwise (ccw) as the solenoid plunger "pulls in".
3. If this does not occur, turn the key switch to the "On" position. press the plunger, by hand, and observe if the plunger remains "pulled in".
4. If the plunger remains pulled in, Check solenoid adjustment (see **FIGURE 19-9**) if not, determine the cause and correct as follows:

   a. *Fuse* – Inspect the electric shutoff fuse. If burned out, replace.

   b. *12 or 24 Volt Supply* – This externally switched solenoid design incorporates a "pull" coil and a "hold" coil which are activated by separate circuits. There are three terminals in the Metri-Pack connector. The wires and the connector of the solenoid are labeled to indicate "common", "pull" or "hold". (Refer to **FIGURE 19-9).**

The "pull" coil is wired into the cranking motor circuit. Check for 12 or 24 volts between the "common" and "pull" terminals of the solenoid mating connector with the key switch in the "start" position [cranking engine].

NOTE:
The minimum voltage required for the 12 volt solenoid to pull in is 9 volts.

NOTE:
The minimum voltage required for the 24 volt solenoid to pull in is 18 volts.

The "hold" coil is wired into the key switch. Check for 12 or 24 volts between the "common" and "hold" terminals of the solenoid mating connector while the key switch is in the "on" position.

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SHUTOFF CABLE/ELECTRIC SHUTOFF

NOTICE: **Do not "jump" or bypass the fuse.**

If voltage available to the (12V or 24V) solenoid is under 12 or 24 VDC, check battery condition, wiring, connections and key switch.

5. *Rubber Boot* – The rubber boot seals the core from dirt and moisture.
   a. Verify that the boot is firmly attached to the solenoid body.
   b. Replace any solenoid which has a torn boot.
   c. Replace the solenoid if the boot becomes hard and inflexible in cold temperatures (–10°F or below). This condition may hinder *"pull-in"* of the solenoid.

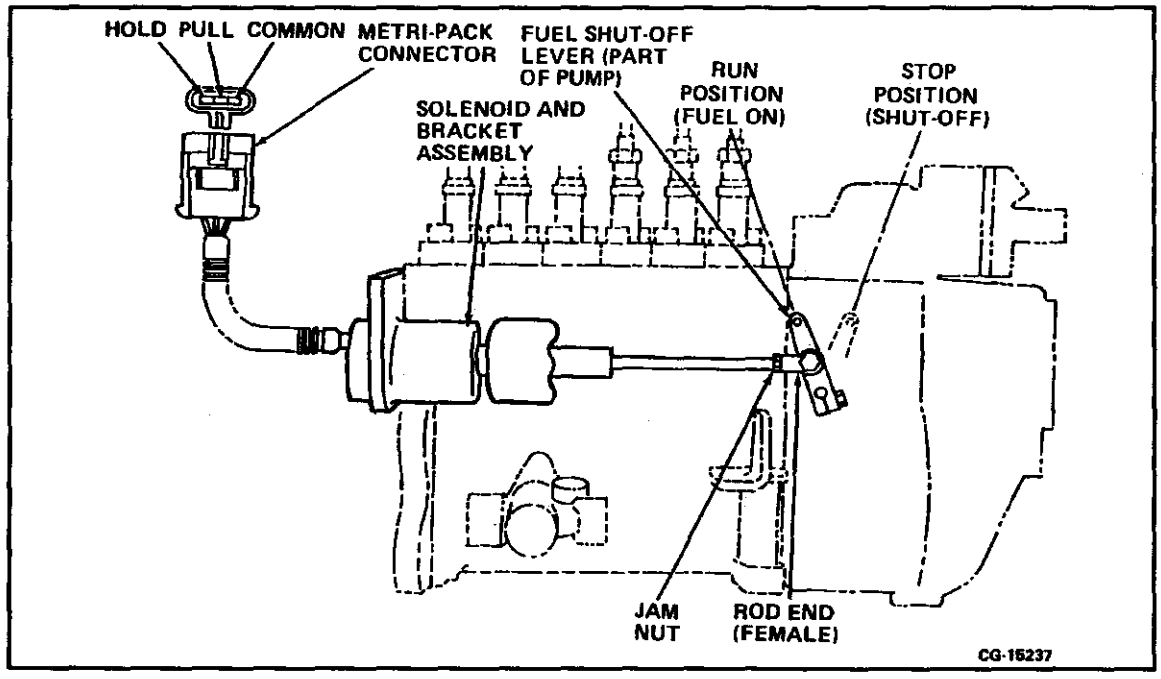

FIGURE 19–8 Electric Shut–off Solenoid

19.4.2.1 Adjustment Procedure

CAUTION

Follow these step by step instructions to prevent solenoid burn out or internal damage to injection pump.

1. Loosen jamnut.
2. Apply the proper D.C. voltage from a power source (with an 8 amp fuse protection) across the "Hold" and "Common" terminals of the solenoid connector.
3. Press solenoid plunger in to bottom of its travel. The plunger should hold the shut–off lever in the "Run Fuel On" position.

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SHUTOFF CABLE/ELECTRIC SHUTOFF

4. Move the shut–off lever toward the RUN position and screw the solenoid swivel (using swivel wrench flats) into the rod end until the shut–off lever stops its forward movement.
5. Turn swivel two full turns in the opposite direction (moving shut–off lever back). Tighten jamnut, then de–energize the solenoid.
6. Cycle the solenoid 2–3 times to insure the shut–off lever travel is adequate to achieve the "RUN" and "SHUT–OFF" positions. This is done by cranking the engine to activate the "PULL" coil causing the plunger to depress and turn the ignition off allowing the plunger to return under spring load. DO NOT CYCLE more than 3 times, additional cycling may cause pull–in coil overheating resulting in burnout.

NOTICE: **The boot should be free of paint which will cause the boot to become soft and catch between the spring and plunger. This will prevent the plunger from seating properly.**

19.4.2.2 Worn Solenoid

Inspect as follows: (**FIGURE 19–9**)

1. Inspect for evidence of dust, dirt, brass powder, or blackened deposits on the plunger or in the solenoid core.

NOTICE: **If evidence of a worn solenoid is found, as described above, solenoid condition is marginal and may not *"pull in"* quickly or consistently.**

2. Measure resistance (ohms) across the terminals of the solenoid as follows:
   a. Be sure the key switch is off. Disconnect the power supply to the solenoid. Connect an Ohm meter to the "Hold" and "Common" terminals **(FIGURE 19–9).**
   b. 12.8 to 16.0 ohms (12V solenoid); 46.7 to 57.1 ohms (24V solenoid) resistance should be observed.
   c. Connect an ohm meter to the "Pull" and "Common" terminals **(FIGURE 19–9).**
   d. .16 to .24 ohms (12V solenoid); .55 to .68 (24V solenoid) ohms resistance should be observed.

NOTICE: **Replace solenoid if resistance measurements exceed specifications**

Resistance Check (No Power to Solenoid)		
Terminals	**12 Volt**	**24 Volt**
Hold to Common	12.8 –16.0 omhs	46.7 – 57.1 omhs
Pull to Common	.16 – .24 omhs	.55 – .68 omhs

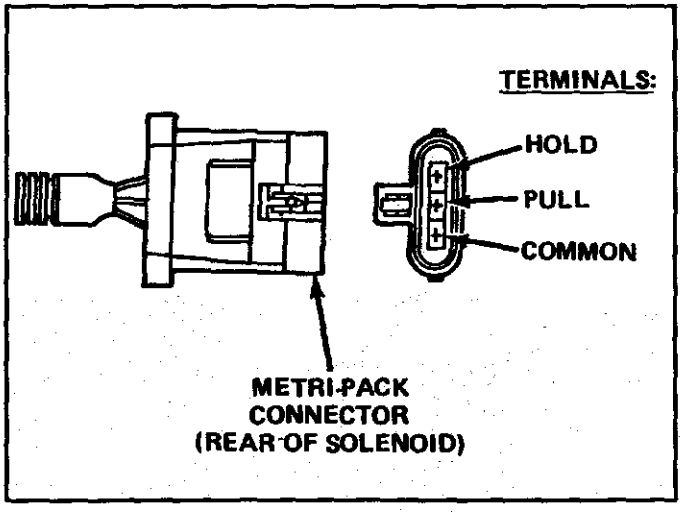

FIGURE 19–9 Solenoid Resistance Check

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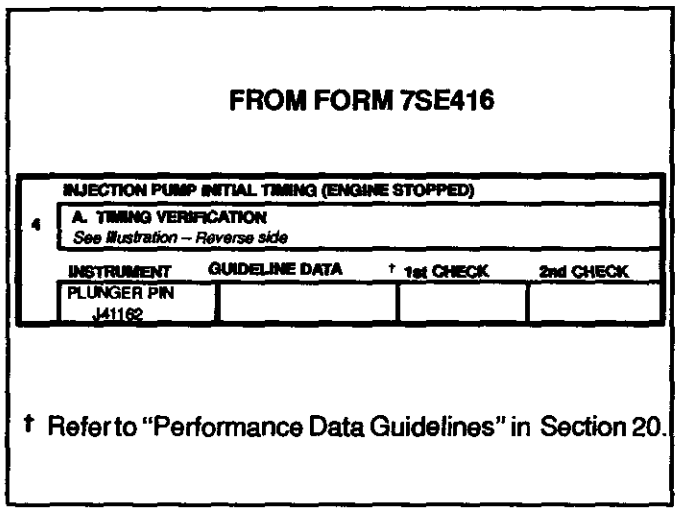
19.5 INJECTION PUMP STATIC TIMING (ENGINE STOPPED) – TEST 4



FROM FORM 7SE416

	INJECTION PUMP INITIAL TIMING (ENGINE STOPPED)			
4	A. TIMING VERIFICATION *See Illustration – Reverse side*			
	INSTRUMENT	GUIDELINE DATA	† 1st CHECK	2nd CHECK
	PLUNGER PIN J41162			

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–10 Injection Pump Static Timing Check

19.5.1 (Static) Timing Check

1. Disconnect battery cables.
2. Remove injection pump gear drive access cover from front of engine and discard O–ring.

NOTICE: **Shut–off must be in the no–fuel position before proceeding.**

3. Rotate the engine in the normal operating direction until the #1 piston is on the compression stroke and the mark on the damper pulley is aligned with the correct timing mark on the timing indicator for the particular engine application. (See "Performance Data Guidelines" in Section 20)

NOTE:

The kidney shaped hole in the injection pump drive gear should be approximately at the 11:00 o'clock position when the #1 piston is on the compression stroke. Refer to FIGURE 19–11.

4. Thread plunger pin (J41162) into timing hole. If plunger pin enters the timing hole, injection timing is ok. If plunger pin does not enter timing hole, remove the plunger pin tool from gear. Loosen the four cap–screws which secure the gear to the injection pump.
5. Rotate injection pump with socket wrench to align the small hole in the drive gear hub with the lock plate hole behind the pump drive hub. Torque the four capscrews which secure the gear to the injection pump using the correct torque specification. Re–thread the timing plunger pin tool into the timing hole. If plunger pin enters timing hole, injection pump timing is correctly set.
6. Remove the plunger timing pin.
7. Re–install gear cover using a new O–ring seal.
8. Enter the observed pump to engine timing in the **1st CHECK** block of 7SE416.

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INJECTION PUMP STATIC TIMING (ENGINE STOPPED)

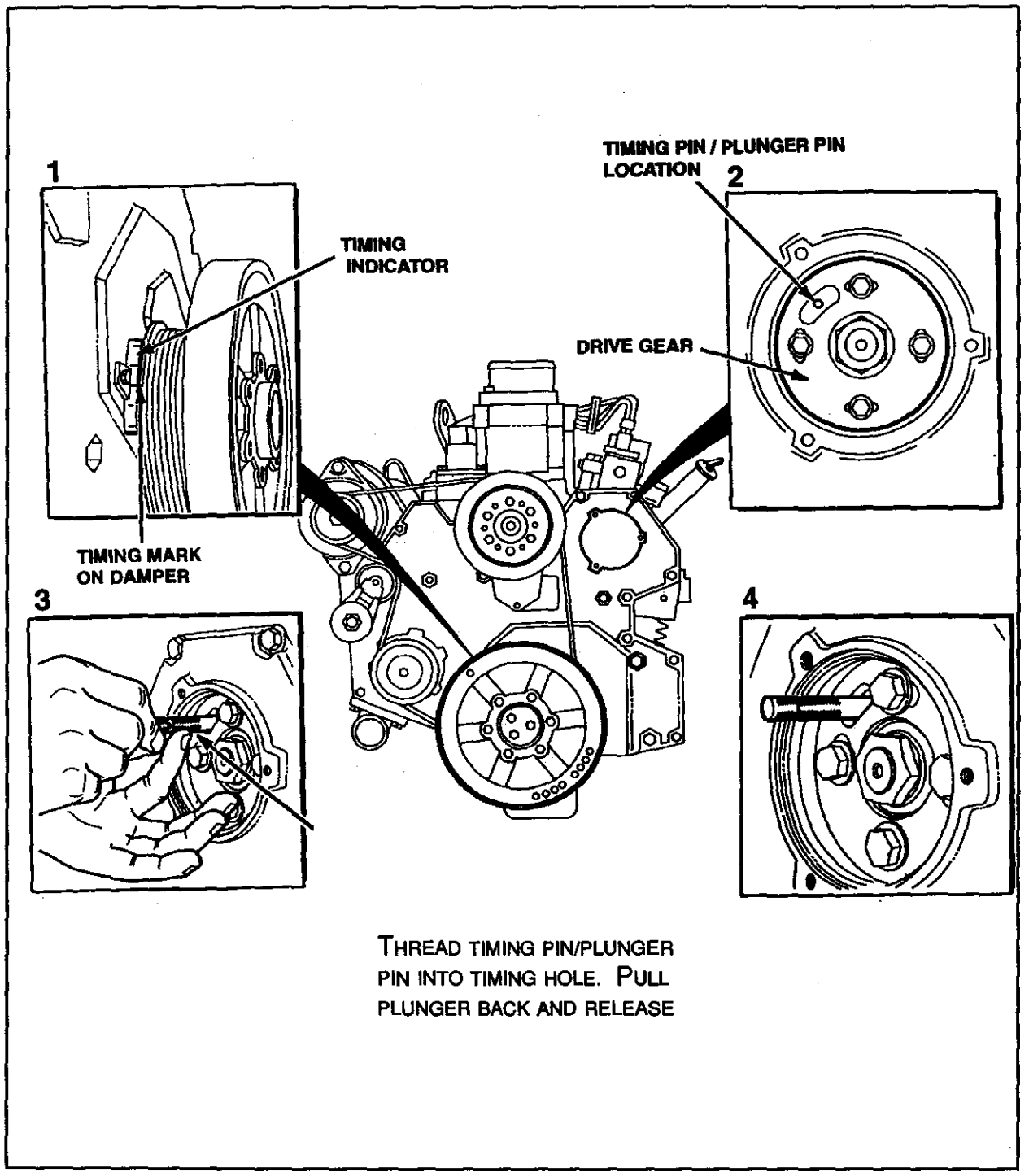

FIGURE 19–11 Static Pump to Engine Timing

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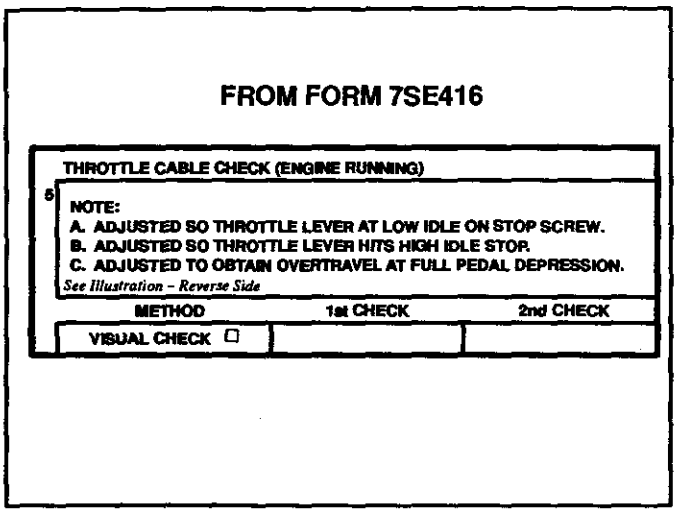
19.6 THROTTLE CABLE CHECK – TEST 5


FROM FORM 7SE416

THROTTLE CABLE CHECK (ENGINE RUNNING)

5 NOTE:
A. ADJUSTED SO THROTTLE LEVER AT LOW IDLE ON STOP SCREW.
B. ADJUSTED SO THROTTLE LEVER HITS HIGH IDLE STOP.
C. ADJUSTED TO OBTAIN OVERTRAVEL AT FULL PEDAL DEPRESSION.
See Illustration – Reverse Side

METHOD	1st CHECK	2nd CHECK
VISUAL CHECK ☐		

FIGURE 19–12 Throttle Cable Check

NOTICE: **Two people are required to properly check throttle cable operation and overtravel. One individual visually inspects throttle cable movement while the other presses the accelerator pedal in the cab with the engine running and the transmission in neutral.**

1. With engine running, transmission in neutral, and accelerator pedal in cab (not being pressed) visually inspect the throttle lever. It should contact the low idle stop screw.
2. The individual visually inspecting throttle cable movement should direct the individual in the cab to slowly press the accelerator pedal. When the throttle lever just contacts the high idle stop screw, the observer should inform the individual in the cab to stop pressing the accelerator pedal and hold that pedal position momentarily.
3. At this point the individual observing throttle cable movement should direct the person in the cab to continue depressing the accelerator pedal to full depression. The observer should see a throttle overtravel of approximately **1/8 in. – 1/4 in.** **(FIGURE 19–13)**

NOTE:

High idle speed and maximum engine horsepower will be obtained when the throttle lever is rotated fully counterclockwise (CCW) and throttle lever contacts high idle stop. Overtravel position ensures that the throttle lever contacts the high idle stop even though slight wear may have occurred in the throttle cable assembly.

4. If the throttle cable overtravel is within the **1/8 in. – 1/4 in** limit, enter OK in the first check box.
5. If required, adjust the throttle cable. Refer to Throttle Cable Adjustment Procedure to achieve the proper **1/8 in. – 1/4 in.** overtravel and indicate correction in the Comments Section of the Performance Analysis Guide.

19.6.1 Throttle Cable Adjustment Procedure

See **FIGURE 19–13.**

1. Disconnect throttle cable from throttle lever.
2. Pull the protective rubber boot back to expose the jamnut.
3. Loosen jamnut.
4. Rotate overtravel cylinder clockwise to increase throttle cable overtravel or counterclockwise to decrease cable overtravel.
5. Retighen jamnut after adjustment and position the protective boot over the exposed jamnut. Reconnect throttle cable to the throttle lever.

NOTICE: **Before starting the engine, enter the operator's compartment and press the throttle pedal several**

THROTTLE CABLE CHECK

times to check for smooth action and full return of the throttle lever and throttle pedal. This *must* be done any time components are replaced, reassembled or adjusted.

6. Refer to the Throttle Cable Check procedure to recheck throttle cable for proper overtravel.

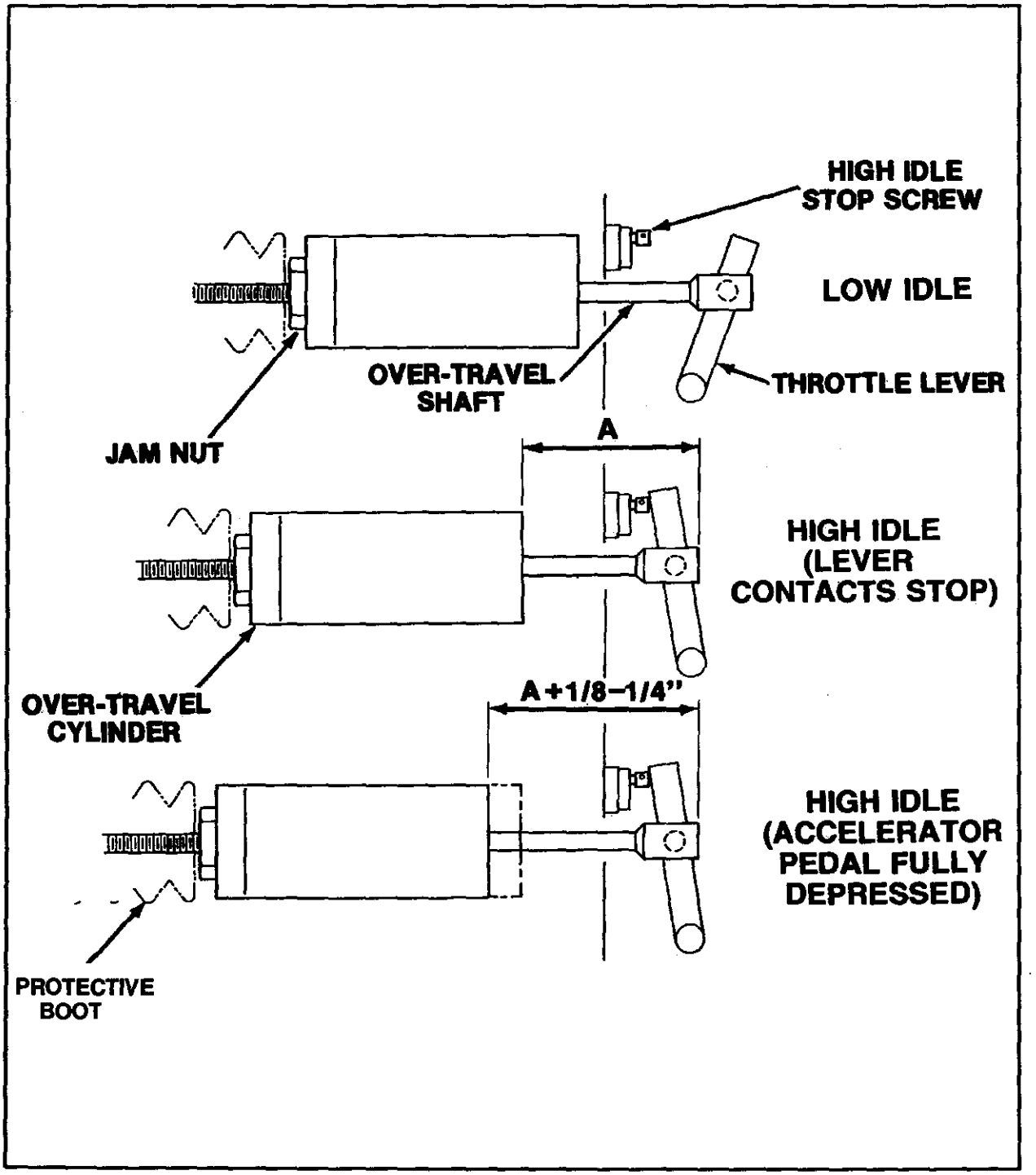


FIGURE 19–13 Throttle Cable Check (Engine Running)

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19.7 LOW IDLE SPEED – TEST 6

FROM FORM NO. 7SE416

	LOW IDLE (RPM)**			
6	A. MANUAL TRANSMISSION – NEUTRAL B. AUTOMATIC TRANSMISSION – DRIVE			
	INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
	MASTER TACHOMETER			

** Engine must be at normal operating temperature.

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–14 The Low Idle Check

To measure low idle speed:

1. Verify the return springs have moved the control lever to the correct low idle position, lever fully towards the governor housing and contacting the low idle stop screw.

NOTICE: **Parking brake must be engaged and wheels blocked with manual transmission in neutral, automatic transmission in gear and engine driven PTO engaged (if applicable).**

2. With the engine running, check low idle speed using an accurate tachometer. See "Performance Data Guidelines" in Section 20 for specifications.
3. If adjustment is required, proceed as directed in Low Idle Adjustment Procedure.

19.7.1 Low Idle Speed Adjustment

(Refer to **FIGURE 19–15**)

1. Loosen the locknut which secures the low idle adjusting screw.
2. Turn the adjusting screw to obtain the specified idle speed. To reduce engine r/min, turn the adjusting screw clockwise. To increase engine r/min, turn the adjusting screw counterclockwise.
3. Tighten the locknut when the specified speed is reached.

NOTE:

To compensate for parasitic loads which affect low idle speed, the low idle speed should be set slightly higher so engine speed will be within specifications when the load is applied. Examples of major parasitic loads are PTO's, Air Compressors, Power Steering Pumps and Alternators.

NOTICE: **If the low idle setting is lower than the minimum allowed, the engine will stall and run rough. if the setting is higher than specified, gear clashing can result in manual transmission applications or harsh engagement in applications with automatic transmissions.**

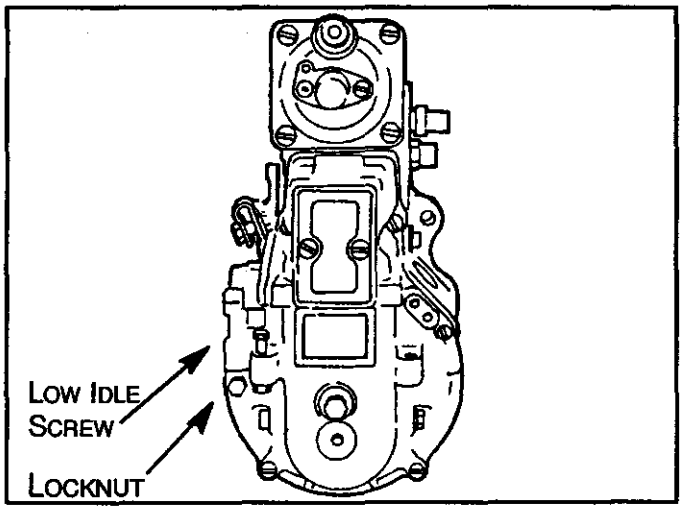

FIGURE 19–15 Low Idle Adjustment

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19.8 HIGH IDLE SPEED (NO LOAD) – TEST 7

FROM FORM NO. 7SE416

HIGH IDLE RPM (NO LOAD)**				
7	THROTTLE LEVER AT MAXIMUM (HIGH IDLE) STOP *See Illustration – Reverse Side*			
	INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
	MASTER TACHOMETER			

** Engine must be at normal operating temperature.

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–16 High Idle Check

Refer to **FIGURE 19–17**

1. With engine running and transmission in neutral, press accelerator pedal in cab to floor (full depression). The throttle lever should contact the (High Idle) stop screw and the throttle cable should be in the overtravel position. Use master tachometer to determine high idle speed.
2. Engine speed on tachometer should be within specifications, outlined in "Performance Data Guidelines," in Section 20.
3. Enter the observed r/min in the **1st CHECK** box.

NOTICE: **The high idle adjustment screw is sealed. Resolve an incorrect high idle condition by following warranty procedures. If the engine is out of warranty, high idle may be adjusted by a qualified technician from an authorized repair facility.**

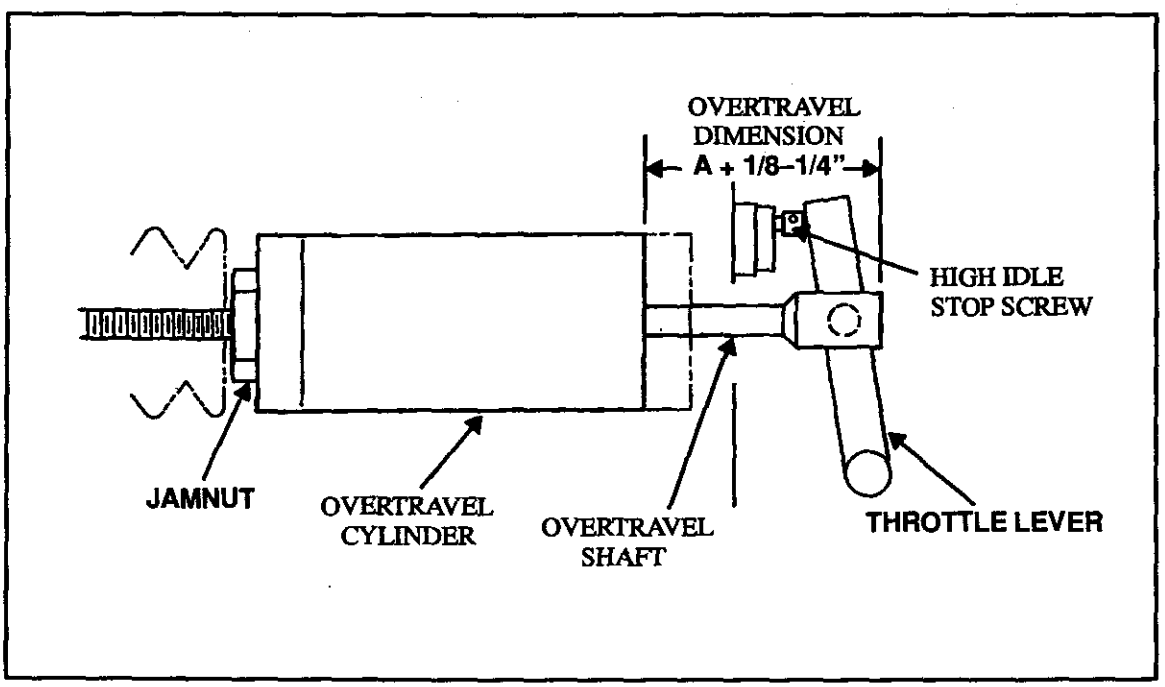

FIGURE 19–17 Throttle Cable – Shown at High Idle with Overtravel

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HIGH IDLE r/min (NO LOAD)

19.8.1 High Idle Adjustment

Refer to **FIGURE 19–18.**

1. Remove the seal from the high idle adjustment screw and loosen the locknut.
2. Turn the screw out (counterclockwise) to reduce high idle.
3. Turn the screw in (clockwise) **(1/2 turn maximum from factory setting)** to increase high idle.
4. Tighten the locknut when the specified high idle speed is reached, then reseal.

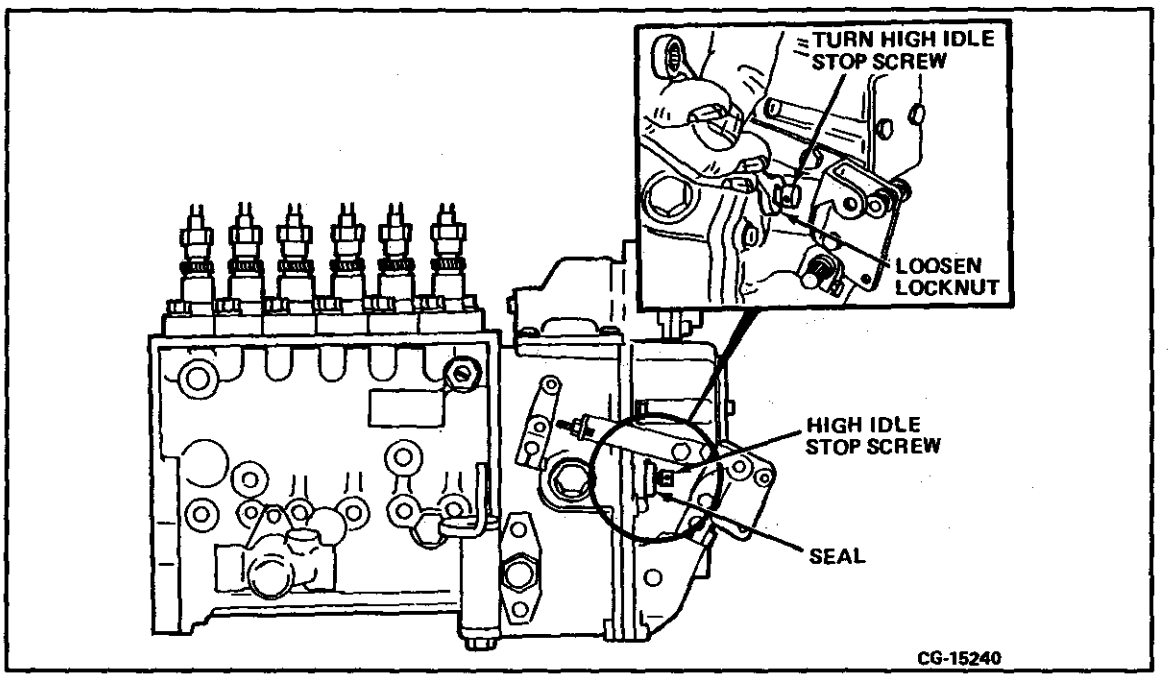

FIGURE 19–18 Figure 5.9. High Idle Adjustment

19.9 AIR CLEANER MAXIMUM RESTRICTION – TEST 8

FROM FORM NO. 7SE416

AIR CLEANER MAXIMUM RESTRICTION

8 A. MEASURE AT HIGH IDLE (NO LOAD).
B. VEHICLES WITH DUAL ELEMENT AIR CLEANERS: VISUALLY INSPECT THE RESTRICTION INDICATOR.
See Illustration – Reverse Side.

INSTRUMENT	GUIDELINE DATA †	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–19 Maximum Air Cleaner Restriction Check

Often a low power and poor fuel economy complaint is simply due to a dirty air cleaner element. In this test, the gauge is inserted in the air intake system downstream of the air cleaner element. As the air cleaner element accumulates dirt, restriction to air flow increases. If restriction exceeds the guidelines, replace the air cleaner element or elements.

19.9.1 Inspect Air Intake Restriction Indicator

1. Refer to appropriate "Operation and Maintenance Manual" "Air Cleaner Restriction Gauge and Indicator", for detailed information.

NOTE:

The air cleaner is to be replaced when the restriction reaches the maximum allowable limit. The restriction can be measured by a service indicator, water manometer or magnahelic gauge.

2. Inspect the element(s) for damaged gaskets or dents in. the element(s). If they exhibit either they should be replaced.

19.9.2 Single Element Air Cleaner

Measure air cleaner restriction as follows:

1. Attach the restriction test gauge **(FIGURE 19–20)** at air cleaner housing tap location.

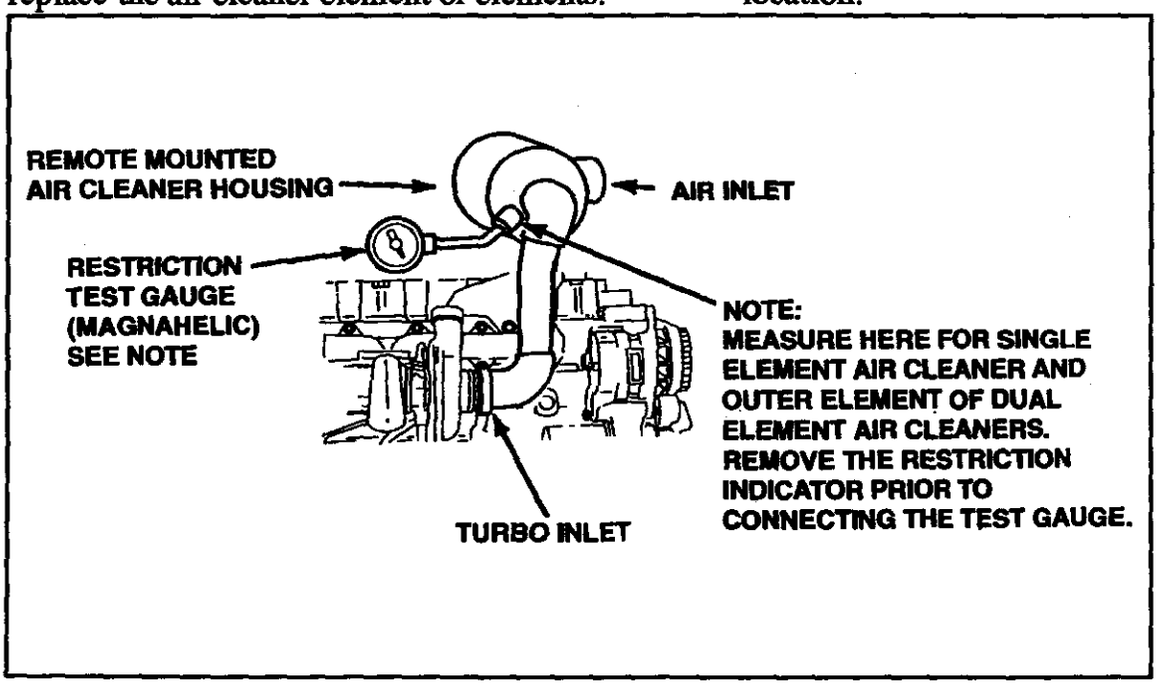

FIGURE 19–20 Restriction Test Location

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AIR CLEANER MAXIMUM RESTRICTION

2. Run engine at high idle r/min.
3. Replace the air cleaner element when the test gauge (**FIGURE 19-20**) shows 12.5 in. H_2O (3.13kPa).

NOTE:

The true maximum air cleaner restriction can only be obtained when operating the engine at full load and rated speed. The vehicle mounted indicator or vacuum gauge will sense maximum restriction. When 25 in. H_2O (6.25 kPa) is sensed on the vehicle mounted gauges, replace the air cleaner element. For convenience, air cleaner restriction can be measured at high idle (no load); however, the element must be replaced when 12.5 in. H_2O (3.13 kPa) is measured.

NOTE:

High air cleaner restriction can cause turbocharger seals to unseat, causing oil to be drawn through seals and into engine.

19.9.3 Dual Element Cleaner

The dual element air cleaner provides a large primary (outer) filter element and a optional small secondary (inner) filter element. The secondary element should be used in dusty environments such as dump and mixer applications.

The current dual element air cleaner assembly air cleaner restriction connection (**FIGURE 19-21** and **FIGURE 19-22**) is located between the primary and the secondary element in the bottom of the air cleaner housing.

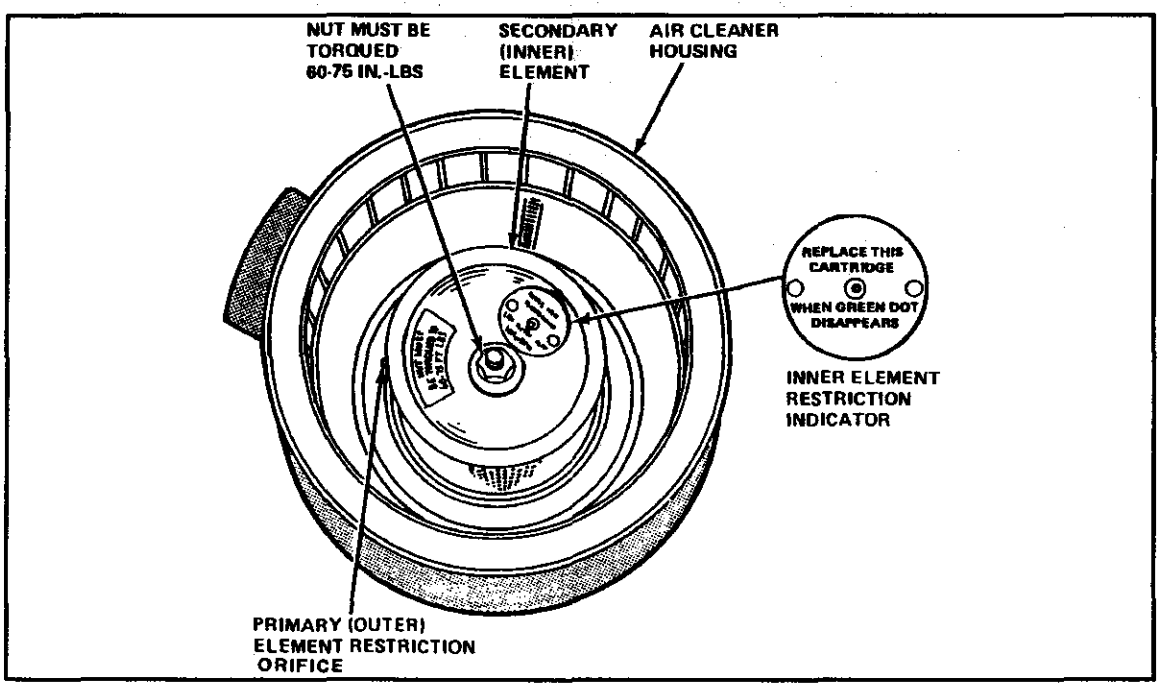

FIGURE 19-21 Dual Element Air Cleaner With Indicator in End Cap

AIR CLEANER MAXIMUM RESTRICTION

This arrangement allows only the primary (outer) element to be sensed by the restriction indicator or dash mounted vacuum gauge. **The inner element is not recorded on the restriction indicator or dashmounted vacuum gauge.**

19.9.4 Visual Check Procedure

To determine inner element restriction use the visual check procedure.

Visually inspect the restriction indicator built into the inner element or inner element retaining nut.

NOTE:

Two different indicators are the result of two different suppliers. Replace the element when the green dot disappears from the element or from the window in the retaining nut.

NOTICE: **Each supplier's retaining nut requires a different torque. Refer to FIGURE 19–21 and FIGURE 19–22.**

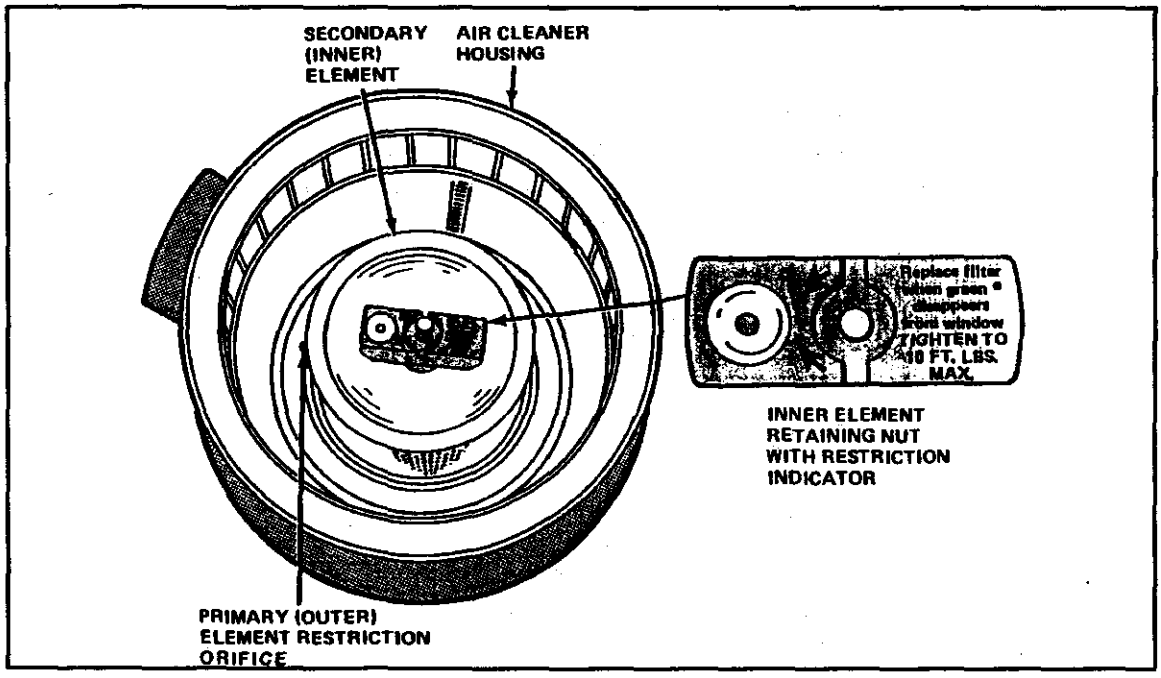

FIGURE 19–22 Dual Element Air Cleaner Retaining Nut Indicator

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AIR CLEANER MAXIMUM RESTRICTION

NOTE:

A low air cleaner restriction reading or a lack of movement by the air cleaner restriction indicator could be caused by a plugged sintered fitting.

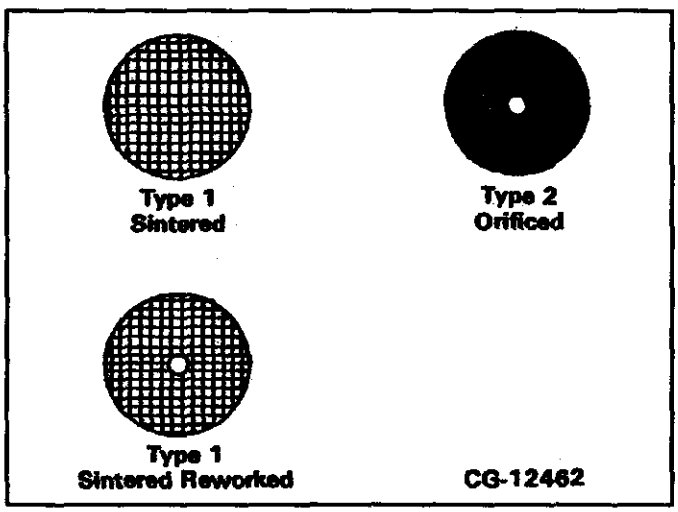

FIGURE 19–23 Restriction Indicator Filter Screening [If Equipped]

There are two different types of this fitting (**FIGURE 19–23**). The first fitting has a filter screen in the fitting. This screen can become plugged and not allow a correct air cleaner restriction reading to be taken. If this type of fitting is found, drill center of screen with a 1/32 in. size drill. This fitting is welded in place and is not a serviceable part. The other type of fitting has a 0.020 in. (0.51mm) orifice fitting. This type of fitting can be easily cleaned with a fine piece of wire. Reworking the first type fitting and cleaning the second type fitting before running diagnostic tests will eliminate false air cleaner restriction readings.

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19.10 TRANSFER PUMP PRESSURE AND INLET RESTRICTION CHECK – TEST 9

FROM FORM 7SE416

	TRANSFER PUMP PRESSURE (MEASURE AT HIGH IDLE) [NO LOAD]**			
9	A. Test at Final Fuel Filter Air Bleed Valve Orifice *See Illustration – Reverse Side*			
	INSTRUMENT	GUIDELINE DATA †	1st CHECK	2nd CHECK
	PRESSURE GAUGE (160 PSI RANGE)			
	IF PRESSURE REMAINS LOW AFTER REPLACING FUEL FILTER, PERFORM STEP B.			
	B. TEST TRANSFER PUMP INLET RESTRICTION: MEASURE AT HIGH IDLE [NO LOAD] *See Illustration – Reverse Side*			
	INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
	VACUUM GAUGE	6 in. Hg. (max.)		

** Engine must be at normal operating temperature.

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–24 Transfer Pump Pressure and Inlet Restriction Check

19.10.1 Test Transfer Pump Pressure

See **FIGURE 19–25.**

1. Remove air bleed valve on fuel filter header.
2. Connect a 1/8 in. fitting to the air bleed valve orifice with a line to a 0–160 lb/in.^{2} pressure gauge on the Model 200 Pressure Test Kit [J39257]. For accurate measurements position the test kit (upright) as shown in **FIGURE 19–25.**

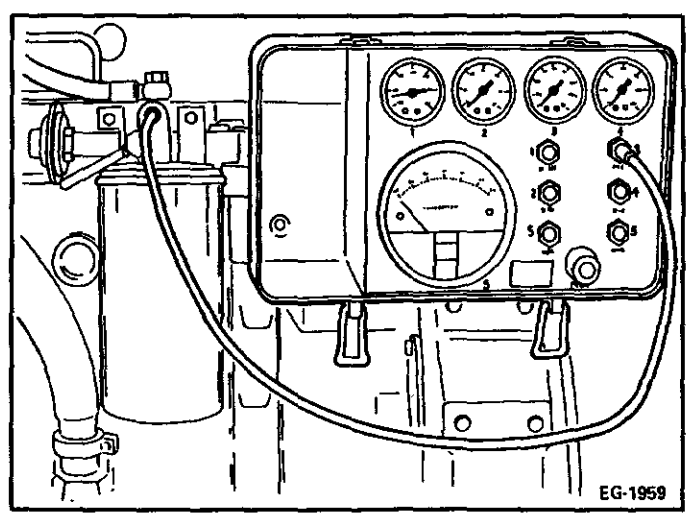

FIGURE 19–25 Measuring Transfer Pump Pressure at Air Bleed Valve Orifice

NOTE:
Bleed the air from the fuel line to insure an accurate reading.

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TRANSFER PUMP PRESSURE AND INLET RESTRICTION CHECK

3. Measure supply pump pressure at high idle r/min, no load. The engine must be at normal operating temperature.
4. Record the pressure in the **1st CHECK** block.
5. If the pressure is less than the guideline data shown in Section 20, clean the pre–strainer and replace the fuel filter. Prime the fuel system and take a second reading.
6. If pressure is still low, perform the Inlet Restriction Test.

NOTE:

If cleaning the pre–strainer and installation of a new final fuel filter corrects the reading, DO NOT check inlet restriction.

NOTE:

The supply pump is very reliable and seldom the cause of low supply pump pressure.

19.10.2 Inlet Restriction Test

See **FIGURE 19–26.**

1. Construct a tee fitting and insert it between the fuel inlet and fuel supply hose.
2. Connect the (0–30 in. Hg range) vacuum gauge to the tee.
3. Run the engine at high idle (no load).
4. Measure and record the restriction in the **1st CHECK** box. For accurate measurements position the test kit (upright) as shown in **FIGURE 19–26.**
5. If restriction exceeds 6 in. Hg, locate the restriction in the fuel flow on the suction side of the pump (i.e. pinched or kinked fuel line or a restricted suction tube in the fuel tank). Correct as necessary.

NOTE:

If fuel is not restricted, replace fuel return valve.

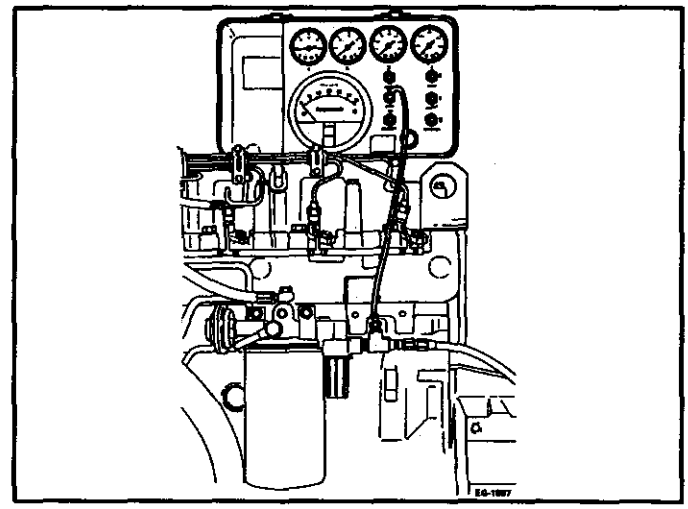

FIGURE 19–26 Fuel Inlet Restriction Test at Supply Inlet

19.11 INTAKE MANIFOLD PRESSURE – TEST 10

FROM FORM 7SE416

	INTAKE MANIFOLD PRESSURE**			
10	A. MEASURE AT FULL LOAD AND AT SPECIFIED SPEEDS. B. SELECT TRANSMISSION GEAR TO ACHIEVE FULL LOAD. *See Illustration – Reverse Side*			
	INSTRUMENT	GUIDELINE DATA †	1st CHECK	2nd CHECK
	PRESSURE GAUGE (30 PSI RANGE)			
	NOTE: IF PRESSURE IS NOT WITHIN LIMITS, GO TO TEST 12.			

** Engine must be at normal operating temperature.
† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–27 Intake Manifold Pressure Check

19.11.1 Intake Manifold Pressure Check

1. Remove pipe plug or ether line from the cold air discharge pipe and install a connector and plastic tubing (**FIGURE 19–28**).
2. Connect the other end of the tubing to the 30 lb/in.^{2} pressure gauge on the Model 200 Pressure Test Kit (J39257).
3. Operate the engine under load until the engine reaches normal operating temperature. Measure the intake manifold pressure at full load and rated speed, and at full load and the specified lower speed. Refer to the "Performance Data Guidelines," in Section 20.
4. Enter the observed manifold pressure in the **1st CHECK** box. If intake manifold pressure is within the specifications shown in the "Performance Data Guidelines," engine power is acceptable. If pressure is not within limits, refer to Wastegate Actuator Condition Test 12.

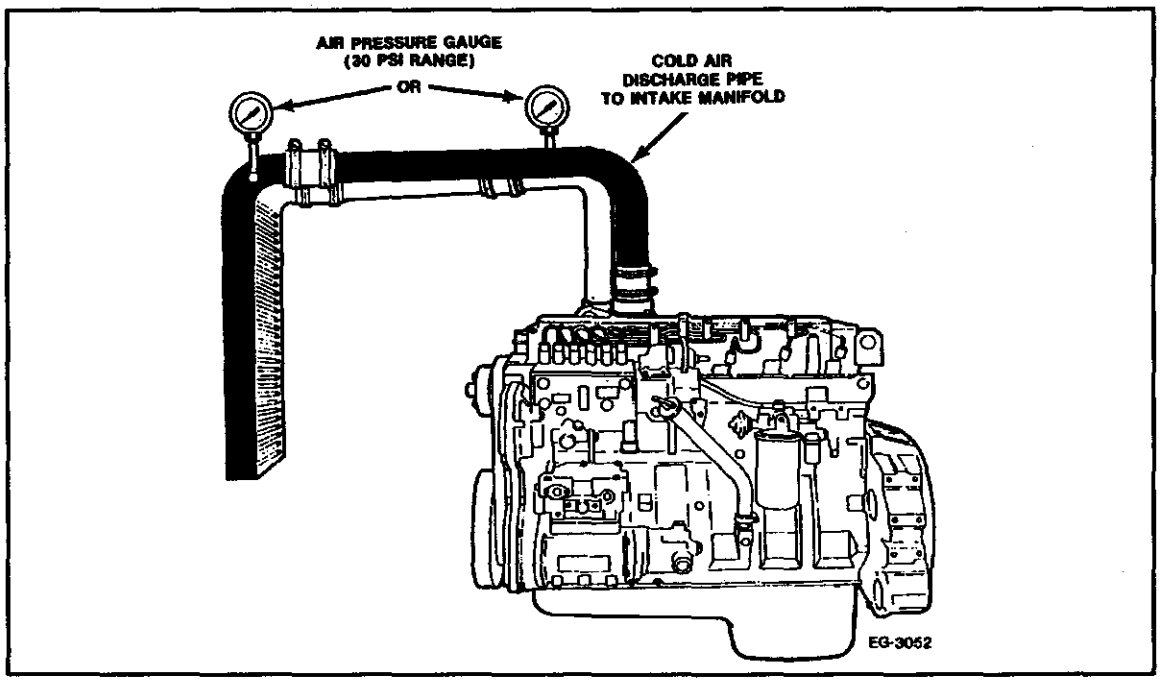

FIGURE 19–28 Intake Manifold Test

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19.12 CRANKCASE PRESSURE – TEST 11

FROM FORM 7SE416

	CRANKCASE PRESSURE**			
11	1. MEASURE @ BREATHER TUBE WITH ORIFICE RESTRICTOR TOOL 2. MEASURE @ HIGH IDLE (NO LOAD) RPM. *See Illustration – Reverse Side*			
	INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
	WATER MANOMETER OR MAGNAHELIC GAUGE			

** Engine must be at normal operating temperature.

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–29 Crankcase Pressure Check

1. Measure crankcase pressure, using breather restrictor tool (J39267), as follows: (See **FIGURE 19–30**).
   a. Park vehicle on level ground.
   b. Insure breather tube is free of dirt and the valve cover/intake manifold is tight.
   c. Insure engine oil level is not above full mark and the dipstick is securely in place.
   d. Connect a line from the restrictor tool to a water manometer or the magnahelic gauge of the Model 200 Pressure Test Kit (J39257).
   e. Run engine to attain normal engine operating temperature before measuring crankcase pressure.
   f. Perform engine crankcase pressure test with engine at high idle (no load) r/min. Allow the gauge reading to stabilize before taking the pressure reading.
   g. Record crankcase pressure in **1st CHECK** box on form 7SE416.
   h. Crankcase pressure for the Series 40 should be 8.0 in. H_2O (max.).

NOTICE: **Do not plug the breather tube during the crankcase pressure test as restricting the tube can cause crankshaft and turbocharger seals to leak.**

2. Excessive crankcase pressure **with** oil consumption trend data indicates:
   a. Badly worn or broken rings and/or
   b. Badly worn or scored cylinder sleeves.
   c. A restricted breather tube.
3. Excessive crankcase pressure **without** significant oil consumption trend data indicates:
   a. Leaking intake manifold/valve cover gasket.
   b. Air compressor effecting crankcase pressure. Remove compressor discharge line to remove its influence.
4. Review the recorded results of the crankcase pressure test. Correct any difference between the guideline data and the **1st CHECK** box and repeat the test.
5. If results obtained during the above tests are within guidelines, engine operation is satisfactory.

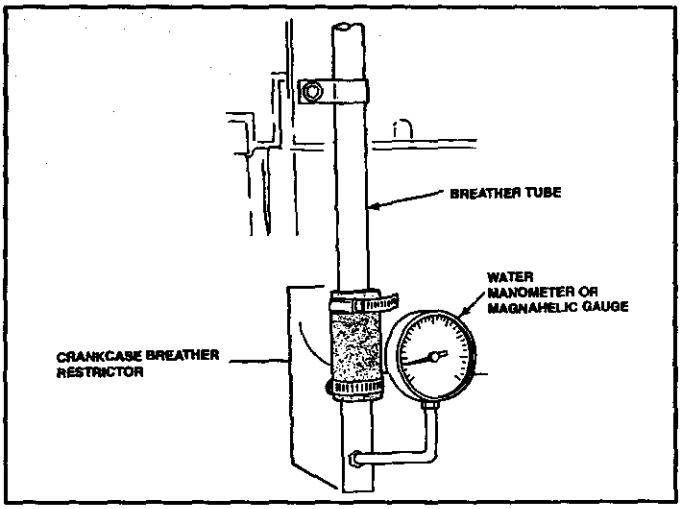

FIGURE 19–30 Crankcase Pressure Test

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19.13 WASTEGATE ACTUATOR CONDITION – TEST 12

FROM FORM 7SE416

12 WASTEGATE ACTUATOR CONDITION

Remove *actuator* boost line from turbo compressor housing. Connect an air regulator with a 0–60 psi gauge to the actuator boost line. Mark actuator shaft with paint pen. Spray leak detector around the actuator housing and slowly apply air pressure to the actuator. Actuator (shaft) movement (indicated by position of paint mark) should begin to occur between 28–30 psi. If a significant amount of actuator shaft movement occurs and no air leaks are detected at actuator housing, actuator is OK. If little or no shaft movement occurs or air leaks are present at the actuator housing, the turbocharger must be removed from engine. Refer to engine service manual for further wastegate actuator diagnosis.

See Illustration – Reverse Side

INSTRUMENT	GUIDELINE DATA	1st CHECK	2nd CHECK
REGULATED AIR SUPPLY WITH PRESSURE GAUGE (0–60 PSI GAUGE)	Actuator movement between 28–30 psi and no air leaks at actuator housing.		

FIGURE 19–31 Waste Actuator Condition Check

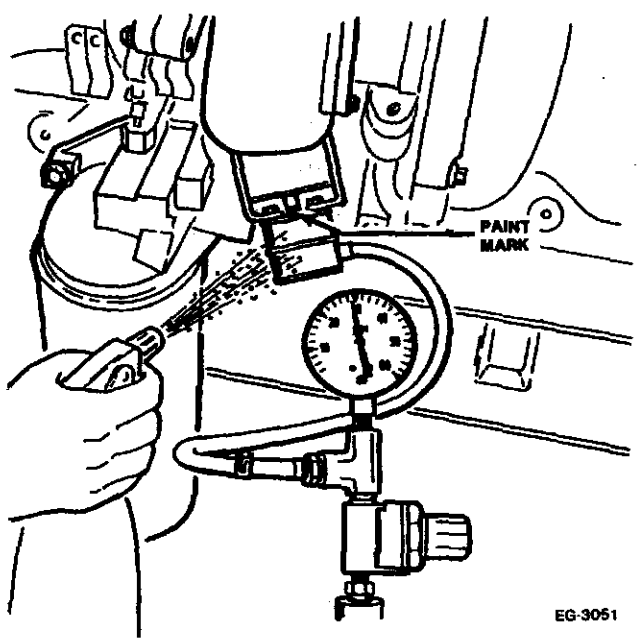

FIGURE 19–32 Wastegate Actuator Test

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19.14 ANEROID DIAPHRAGM – TEST 13

FROM FORM 7SE416

ANEROID DIAPHRAGM			
13	PRESSURE TEST DIAPHRAGM (20 PSI MAX. – FOR 30 SECONDS). NO LEAKAGE PERMISSIBLE. *See Illustration–Reverse Side*		
	INSTRUMENT	1st CHECK	2nd CHECK
	MODEL 200 PRESSURE KIT		

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–33 Aneroid Diaphragm Check

1. Remove intake manifold to aneroid line at aneroid.
2. Connect fitting and plastic tubing to Model 200 Pressure Test Kit [J39257]. Use 0–30 lb/in.^{2} gauge. For accurate measurements position the test kit (upright) as shown in **FIGURE 19–34.**
3. Pressurize diaphragm housing to 20 lb/in.^{2} maximum for 30 seconds. (See **FIGURE 19–34**).
4. No leakage is acceptable. Record whether aneroid leaks. Injection pump must be removed if diaphragm leaks because full load stop must be set on injection pump test bench.

NOTE:

If an alternate method of pressurizing the diaphragm is used, other than the Pressure Kit [J39257], air must be pressure regulated and filtered.

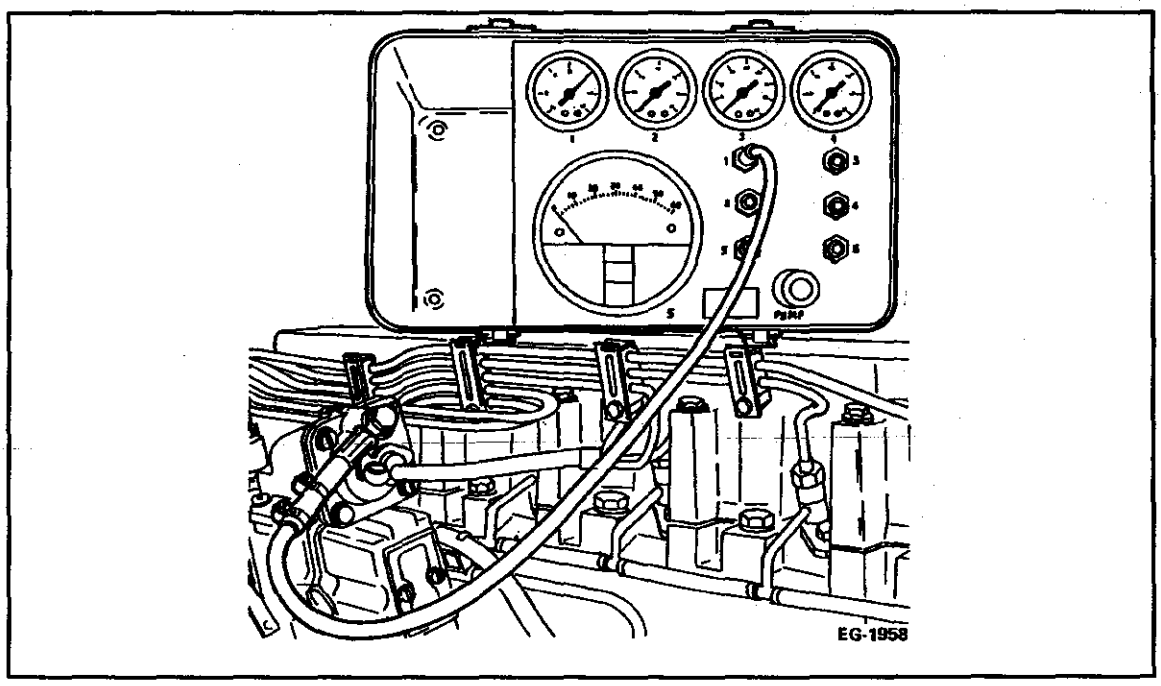
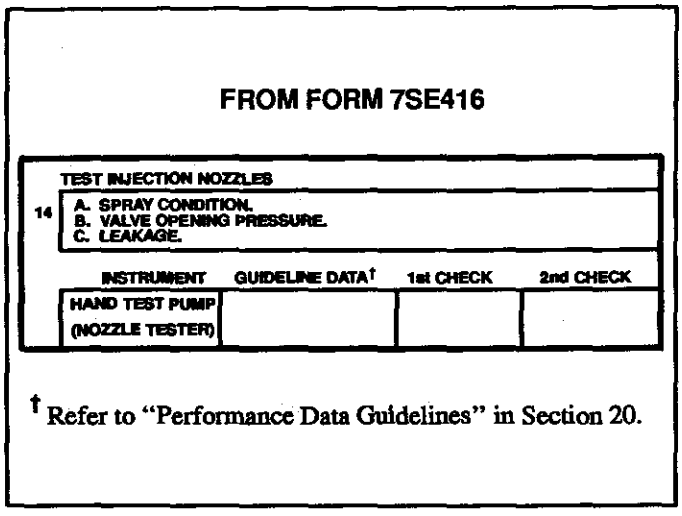


FIGURE 19–34 Aneroid Diaphragm Leakage Test

19.15 TEST INJECTION NOZZLES – TEST 14



FROM FORM 7SE416

	TEST INJECTION NOZZLES			
14	A. SPRAY CONDITION. B. VALVE OPENING PRESSURE. C. LEAKAGE.			
	INSTRUMENT	GUIDELINE DATA†	1st CHECK	2nd CHECK
	HAND TEST PUMP (NOZZLE TESTER)			

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–35 Test Injection Nozzles

This is a functional test of injection nozzle performance. Nozzles must be removed from the engine and tested for spray condition, valve opening pressure and leakage.

NOTE:

If proper tools and facilities are not available to test or repair nozzles and nozzles are the suspected problem they should be serviced at an authorized service center or they should all be replaced with new or renewed nozzles.

NOTICE: **In outlining the procedure for inspection of injection nozzles, the necessity of cleanliness cannot be over–emphasized. A clean workbench, clean washing fluid and clean tools are all essential to produce satisfactory results. The use of suitable tools for this type of work is equally important.**

1. Injection Nozzle Removal:

   a. Clean the top of the engine to prevent dirt from entering any openings.

   b. Detach high–pressure tubing and leak–off lines, covering their opening ends with plastic caps to protect against the entrance of dirt.

   c. Remove mounting (crab) bolt and clamp. Pull nozzle assembly from the cylinder head, being careful not to strike the end of the nozzle against any hard surface. If the assembly seems to be stuck, break it loose from carbon deposits to facilitate removal.

   d. Cover nozzle openings with protector caps to prevent the entrance of dirt. Also protect nozzle tip with protective caps.

   e. Remove injection nozzle gasket from nozzle bore with a suitable tool and discard.

2. Injection Nozzle Testing:

   The prime requirements for a satisfactory nozzle assembly are: pressure tight seats; no excessive valve stem leakage; satisfactory spray and atomization characteristics.

   a. After removal from engine, test nozzles for spray condition, opening pressure and leakage on a hand test pump J29075–150.

NOTICE: **It is advisable to test nozzles before cleaning them. After testing, place nozzles in a cold decarbonizing solution for at least one hour. After removing nozzles from solution, wash off the outside surfaces.**

   b. Check nozzle opening pressure. Open the gauge valve, operate the test pump in slow, smooth, even strokes and observe gauge pressure to determine pressure at which nozzle opens (discharges fluid). The nozzle should operate within the specified opening pressure range.

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TEST INJECTION NOZZLE

FIGURE 19-36 shows an injection nozzle mounted for testing on the hand test pump.

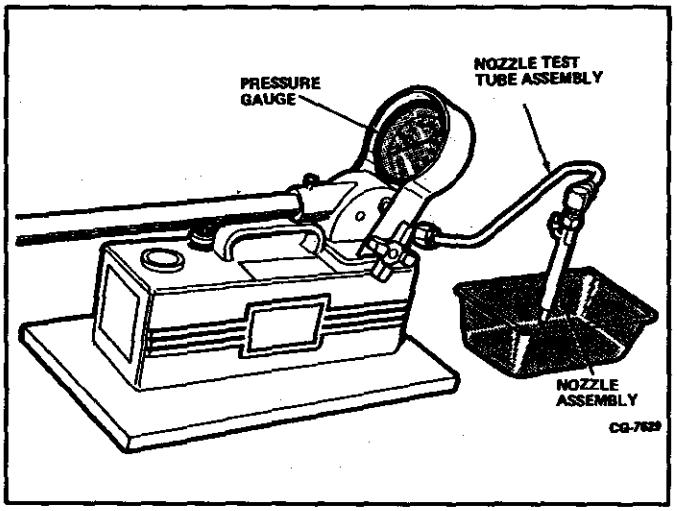

FIGURE 19-36 Typical Nozzle Assembly Mounted in the Hand Test Pump

c. Prepare pump for making tests. Fill pump reservoir with Viscor 1487AW (SAE J967D) calibration fluid. Open pump valve slightly and operate pump handle to expel air from pump and outlet pipe. Operate pump until solid fluid (without air bubbles) flows from end of outlet pipe. Close pump valve.

d. Connect injection nozzle to test pump. Avoid "cross-threading." Tighten connector nut securely with open end wrench.

NOTE:

The gauge valve should be closed. Failure to close the gauge valve will lead to a damaged gauge. The gauge valve should only be opened to check opening pressure and tip leakage. A residual pressure should always be left in the pressure gauge.

e. Bleed air from the nozzle. Open the pump valve and operate the pump for several quick strokes to expel (bleed) air from the injection nozzle. Fluid should discharge from the holes in the nozzle tip.

CAUTION

Keep hands away from the nozzle discharge. Fluid discharging from the nozzle under high pressure can penetrate the skin and cause infection. Medical attention should be provided immediately in the event of skin penetration.

f. **Observe The Discharge Pattern.** Operate the test pump in smooth, even strokes and observe the pattern of fluid discharging from the nozzle tip discharge holes. The discharge should be well atomized in an even pattern, free from solid streams and dribbling. Refer to **FIGURE 19-37.**

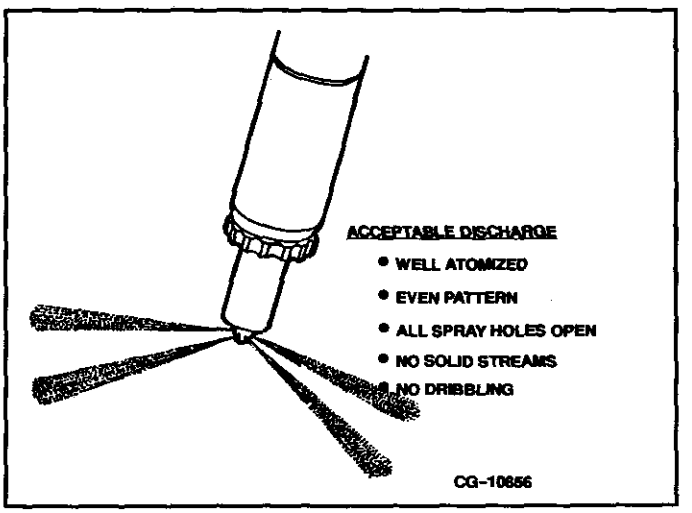

FIGURE 19-37 Acceptable Nozzle Discharge

TEST INJECTION NOZZLES

Specified Valve Opening Pressure Chart

New or Rebuilt .. 3675 lb/in.^{2} ± 75 lb/in.^{2}
..... (25,338 kPa ± 517 kPa)
Minimum Permissible ... 2900 lb/in.^{2}
(Used) (20,000 kPa)

g. **Check For Tip Leakage.** Blow nozzle tip dry using filtered compressed air. Operate test pump to maintain pressure at about 500 lb/in.^{2} (3447 kPa) below opening pressure. Nozzle tip should remain dry without an accumulation of fluid drops at spray holes. A slight wetting after about 5 seconds is permissible if no droplets are formed. Refer to FIGURE 19-38.

NOTICE: **Do not wipe tip with fingers as this will tend to draw the fluid present in the sac hole through the orifices and falsely indicate a leak and rejection of a good valve.**

h. **Check Fuel Leak-off.** Operate test pump in quick strokes and observe for flow of fluid from leak-off part of nozzle. A very slight leak-off is normal. If an excessive amount of fluid is expelled or if fluid surges from leak-off port when test pump is operated, nozzle is faulty.

If nozzle passes above tests, it is suitable for further service in the engine following cleaning and removal of accumulated carbon. Nozzles showing irregular spray pattern, leakage at nozzle tip spray holes, excessive fluid leak-off or opening pressure below minimum permissible limit should be replaced or serviced (disassembled, cleaned and rebuilt).

3. Injection Nozzle Installation:

a. Thoroughly clean nozzle bore in cylinder head before reinserting nozzle holder assembly. Pay particular attention to seating surfaces, in order that no small particles or carbon will cause assembly to be cocked or permit blow-by of combustion gases. Don't use hard or sharp tools for cleaning. A round piece of brass properly shaped or a round fine steel bristle brush is permitted if used with care.

b. Install nozzle assemblies with correct thickness copper gasket, carefully held in place with a dab of grease, into its bore.

NOTE:
Make sure old nozzle gasket is not left in bore.

c. Tighten the nozzle crab bolts to 19 lb·ft. (25N·m).

d. Reconnect the fuel supply and return lines to the nozzles. Tighten the fuel supply line fittings to their specified torques.

e. Operate engine and check for fuel or combustion gas leakage.

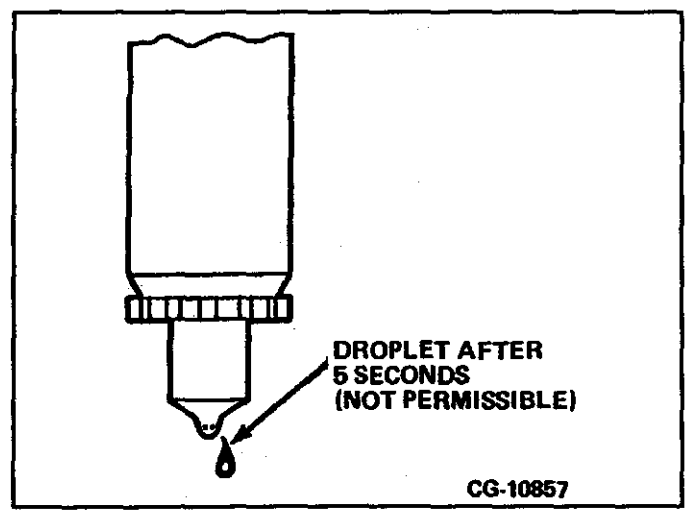

FIGURE 19-38 Unacceptable Nozzle Tip Leakage

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19.16 EXHAUST BACK PRESSURE – TEST 15

FROM FORM 7SE416

EXHAUST BACK PRESSURE

15 A. MEASURE AT A POINT 3 TO 6 IN. AFTER THE EXHAUST ELBOW.
B. MEASURE AT FULL LOAD AND RATED SPEED.
See Illustration – Reverse Side.

INSTRUMENT	GUIDELINE DATA †	1st CHECK	2nd CHECK
WATER MANOMETER OR MAGNAHELIC GAUGE			

† Refer to "Performance Data Guidelines" in Section 20.

FIGURE 19–39 Exhaust Back Pressure Check

Measure exhaust back pressure as follows:

1. Drill and braze on a 1/8 in. NPT male connector in a straight section of exhaust pipe approximately 3 to 6 inches after the bend in the exhaust pipe. Refer to **FIGURE 19–40.**
2. Connect a minimum of one foot coiled copper tubing to the connector before attaching the plastic tubing from the Model 200 Pressure Test Kit (J39257).

NOTE:
The coiled copper tubing prevents the plastic tubing from melting.

3. Connect the other end of the plastic tubing to the magnahelic gauge on the Pressure Test Kit or a water manometer.
4. Obtain the data at rated speed on a chassis dynamometer or fully loaded on the highway. The engine must be at normal operating temperature. Specifications as noted in the "Performance Data Guidelines" in Section 20 are 0–27 in. H_2O (0–6.7 kPa).
5. Pressures which exceed the guidelines indicate a restriction in the exhaust system which can cause a reduction in engine power. Reduce restriction by replacing the muffler or exhaust piping as required.

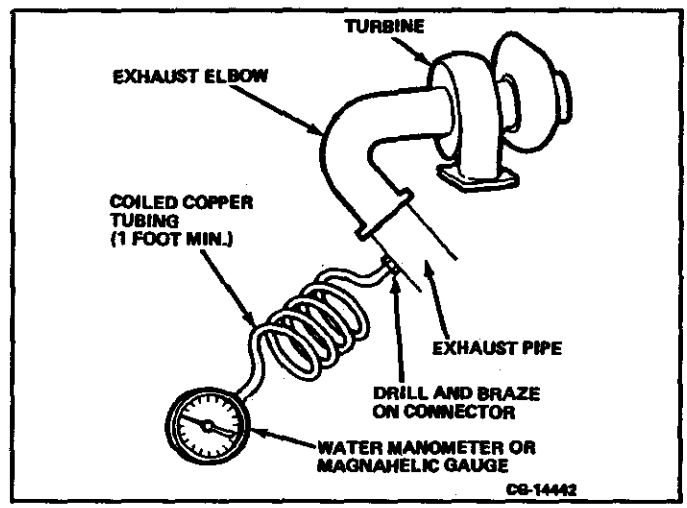

FIGURE 19–40 Exhaust Back Pressure Test Location