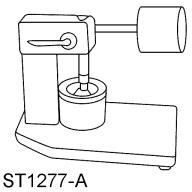
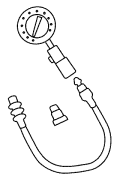
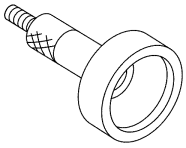
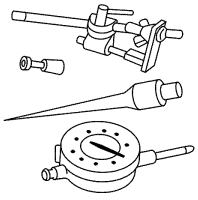
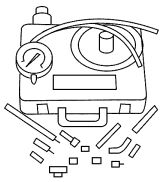
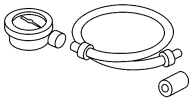
DIAGNOSIS AND TESTING

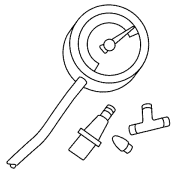
Engine

Special Tool(s)

 ST1277-A	Commercially Available Hydraulic Lash Adjuster Leakdown Tester —
 ST1299-A	Quick Disconnect Compression Tester 134-R0212 or equivalent
 ST1272-A	Dial Indicator Gauge Adapter 303-007 (TOOL-6565-AB) or equivalent
 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent
 ST1298-A	Engine Cylinder Leak Detection/Air Pressurization Kit 014-00708 or equivalent
 ST1296-A	Oil Pressure Gauge 303-088 (T73L-6600-A)

(Continued)

Special Tool(s)

 ST1300-A	UV Leak Detector Kit 164-R0756 or equivalent
 ST1297-A	Vacuum/Pressure Tester 164-R0253 or equivalent

Material

Item	Specification
Gasoline Engine Oil Dye 164-R3705	ESE-M99C103-B1
Motorcraft SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP (in Canada Motorcraft SAE 5W-20 Super Premium Motor Oil CXO-5W20-LSP12) or equivalent — 4.6L (3V)	WSS-M2C930-A
Motorcraft SAE 5W-30 Premium Synthetic Blend Motor Oil XO-5W30-QSP (in Canada Motorcraft SAE 5W-30 Super Premium Motor Oil CXO-5W30-LSP12) or equivalent — 4.0L SOHC	WSS-M2C929-A

DIAGNOSIS AND TESTING (Continued)

Inspection and Verification

⚠ WARNING: To avoid the possibility of personal injury or damage to the vehicle, do not operate the engine with the hood open until the fan blade has been examined for possible cracks and separation.

NOTE: Specifications show the expected minimum or maximum condition. Refer to the appropriate section in Group 303 for the procedure.

NOTE: If a component fails to meet the specifications, it is necessary to install a new component or refinish. If the component can be refinished, wear limits are provided as an aid to making a decision. A new component must be installed for any component that fails to meet specifications and cannot be refinished.

1. Verify the customer concern by operating the engine to duplicate the condition.
2. Visually inspect for obvious signs of mechanical damage. Refer to the following chart.

Visual Inspection Chart

Mechanical
• Engine coolant leaks • Engine oil leaks • Fuel leaks • Damaged or severely worn parts • Loose mounting bolts, studs and nuts

3. If the inspection reveals obvious concerns that can be readily identified, repair as necessary.
4. If the concerns remain after the inspection, determine the symptoms. GO to Symptom Chart.

Symptom Chart

Symptom Chart

Condition	Possible Sources	Action
• Difficult starting	• Damaged ignition system. • Damaged fuel system. • Damaged starting system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Damaged charging system/battery.	• REFER to Section 414-00.
	• Burnt valve. • Worn piston.	• INSTALL a new valve. • For 4.0L engines, INSTALL a new piston and connecting rod assembly. For 4.6L engines, INSTALL a new piston.
	• Worn piston rings. • Worn cylinder.	• INSTALL new piston rings. • REPAIR or INSTALL a new cylinder block.
	• Damaged head gasket. • Damaged cooling system.	• INSTALL a new head gasket. • Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Poor idling	• Vacuum leaks. • Malfunctioning or damaged ignition system. • Malfunctioning or damaged fuel system. • Damaged valve tappet or lash adjuster. • Damaged valve tappet guide or lash adjuster. • Incorrect valve-to-valve seat contact. • Damaged head gasket. • Worn or damaged engine support brackets. • Worn or damaged engine support insulators. • Worn or damaged transmission insulator and retainer.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual. • INSTALL a new valve tappet or lash adjuster. • INSTALL a new valve tappet guide or valve tappet. • REPAIR or INSTALL a new valve or valve seat. • INSTALL a new head gasket. • INSTALL a new engine support brackets. • INSTALL a new engine support insulator. • INSTALL a new transmission insulator and retainer.
• Abnormal combustion	• Malfunctioning or damaged fuel system. • Malfunctioning or damaged ignition system. • Malfunctioning or damaged air intake system. • Damaged valve tappet or lash adjuster. • Damaged valve tappet guide or valve tappet. • Burnt or sticking valve. • Weak or broken valve spring. • Carbon accumulation in combustion chamber.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual. • INSTALL a new valve tappet or lash adjuster. • INSTALL a new valve tappet guide or valve tappet. • REPAIR or INSTALL a new valve. • INSTALL a new valve spring. • ELIMINATE carbon buildup.
• Excessive oil consumption	• Leaking oil. • Malfunctioning PCV system. • Worn valve stem seal. • Worn valve stem or valve guide. • Sticking piston rings. • Worn piston ring groove. • Worn piston or cylinder.	• REPAIR oil leakage. • REPAIR or INSTALL new necessary components. • INSTALL a new valve stem seal. • INSTALL a new valve and valve guide. • For 4.0L engines, INSTALL a new piston and connecting rod assembly. For 4.6L engine, REPAIR or INSTALL new piston rings. • For 4.0L engine, INSTALL a new piston and connecting rod assembly. For 4.6L engine, INSTALL a new piston and piston pin. • REPAIR or INSTALL a new piston or cylinder block.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Engine noise	• Leaking exhaust system.	• REPAIR exhaust leakage.
	• Incorrect drive belt tension.	• REFER to Section 303-05.
	• Malfunctioning generator bearing.	• Refer to the appropriate section in Group 414 for the procedure.
	• Malfunctioning coolant pump bearing.	• REFER to Section 303-03.
	• Malfunctioning or damaged cooling system.	
	• Malfunctioning or damaged fuel system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Loose timing chain/belt.	• ADJUST or INSTALL a new timing chain/belt.
	• Damaged timing chain tensioner.	• INSTALL a new timing chain tensioner.
	• Excessive main bearing clearance.	• **CAUTION: Remove the cylinder heads before removing the crankshaft. Failure to do so can result in engine damage.** ADJUST clearance or INSTALL new crankshaft main bearings.
	• Seized or heat-damaged crankshaft main bearing.	• INSTALL new crankshaft main bearings.
	• Excessive crankshaft end play.	• INSTALL a new thrust bearing or crankshaft.
	• Excessive connecting rod bearing clearance.	• INSTALL new connecting rod bearings or connecting rods.
	• Heat damaged connecting rod bearing.	• INSTALL new connecting rod bearings.
	• Damaged connecting rod bushing.	
	• Worn cylinder.	• REPAIR or INSTALL a new cylinder block.
	• Worn piston or piston pin.	• INSTALL a new piston or piston pin.
	• Damaged piston rings.	• INSTALL new piston rings.
	• Bent connecting rod.	• INSTALL a new connecting rod.
	• Malfunctioning valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Excessive valve tappet or lash adjuster clearance.	• ADJUST clearance or INSTALL a new valve tappet guide or valve tappet.
	• Broken valve spring.	• INSTALL a new valve spring.
	• Excessive valve guide clearance.	• ADJUST clearance or INSTALL a new valve guide or valve.

DIAGNOSIS AND TESTING (Continued)

Symptom Chart (Continued)

Condition	Possible Sources	Action
• Insufficient power	• Malfunctioning or damaged ignition system. • Electronic throttle control (ETC) system concerns. • Malfunctioning or damaged fuel system. • Malfunctioning or damaged air intake system.	• Refer to the appropriate section in Group 303 for the procedure. REFER to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.
	• Damaged or plugged exhaust system.	• INSPECT exhaust system.
	• Incorrect tire size.	• REFER to Section 204-00.
	• Dragging brakes.	• REFER to Section 206-00.
	• Slipping transmission.	• Refer to the appropriate section in Group 307 for the procedure.
	• Malfunctioning valve tappet or lash adjuster.	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide or valve tappet.	• INSTALL a new valve tappet guide or valve tappet.
	• Compression leakage at valve seat.	• REPAIR or INSTALL a new valve, valve seat or cylinder head.
	• Seized valve stem.	• INSTALL a new valve.
	• Weak or broken valve spring.	• INSTALL a new valve spring.
	• Worn or damaged camshaft.	• INSTALL a new camshaft.
	• Damaged head gasket.	• INSTALL a new head gasket.
	• Cracked or distorted cylinder head.	• INSTALL a new cylinder head.
	• Damaged, worn or sticking piston ring(s).	• REPAIR or INSTALL a new piston ring(s).
	• Worn or damaged piston.	• INSTALL a new piston and piston pin.

Component Tests

Engine Oil Leaks

NOTE: When diagnosing engine oil leaks, the source and location of the leak must be positively identified prior to repair.

Prior to carrying out this procedure, clean all sealing surface areas with a suitable solvent to remove all traces of oil.

Engine Oil Leaks — Fluorescent Oil Additive Method

Use the UV Leak Detector Kit to carry out the following procedure for oil leak diagnosis.

1. Add gasoline engine oil dye. Use a minimum 14.8 ml (0.5 ounce) to a maximum 29.6 ml (1 ounce) of fluorescent additive to all engines. If the oil is not premixed, fluorescent additive must first be added to crankcase.
2. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the UV Leak Detector Kit. A clear bright yellow or orange area will identify the leak. For extremely small leaks, several hours may be required for the leak to appear.

Leakage Points — Underhood

Examine the following areas for oil leakage:

- valve cover gaskets
- intake manifold gaskets
- cylinder head gaskets
- oil bypass filter
- oil filter adapter
- engine front cover
- oil filter adapter and filter body
- oil level indicator tube connection
- oil pressure sensor

DIAGNOSIS AND TESTING (Continued)

Leakage Points — Under Engine — With Vehicle on Hoist

Examine the following areas for oil leakage:

- oil pan gaskets
- oil pan sealer
- oil pan rear seal
- engine front cover gasket
- crankshaft front seal
- crankshaft rear oil seal
- crankshaft main bearing cap side bolts
- oil filter adapter and filter body
- oil cooler, if equipped

Leakage Points — With Transmission and Flywheel Removed

Examine the following areas for oil leakage:

- crankshaft rear oil seal
- rear main bearing cap parting line
- rear main bearing cap and seals
- flywheel mounting bolt holes (with flywheel installed)
- camshaft rear bearing covers or pipe plugs at the end of oil passages

Oil leaks at crimped seams in sheet metal parts and cracks in cast or stamped parts can be detected when using the dye method.

Compression Test — Compression Gauge Check

1. Make sure the oil in the crankcase is of the correct viscosity and at the correct level and that the battery is correctly charged. Operate the vehicle until the engine is at normal operating temperature. Turn the ignition switch to the OFF position, then remove all the spark plugs.
2. Set the throttle plates in the wide-open position.
3. Install a compression gauge such as the Compression Tester in the No. 1 cylinder.
4. Install an auxiliary starter switch in the starting circuit. With the ignition switch in the OFF position, and using the auxiliary starter switch, crank the engine a minimum of 5 compression strokes and record the highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat the test on each cylinder, cranking the engine approximately the same number of compression strokes.

Compression Test — Test Results

The indicated compression pressures are considered within specification if the lowest reading cylinder is at least 75 percent of the highest reading. Refer to the Compression Pressure Limit Chart.

Compression Pressure Limit Chart

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
924 kPa (134 psi)	696 kPa (101 psi)	1131 kPa (164 psi)	848 kPa (123 psi)	1338 kPa (194 psi)	1000 kPa (146 psi)	1544 kPa (224 psi)	1158 kPa (168 psi)
938 kPa (136 psi)	703 kPa (102 psi)	1145 kPa (166 psi)	855 kPa (124 psi)	1351 kPa (196 psi)	1014 kPa (147 psi)	1558 kPa (226 psi)	1165 kPa (169 psi)
952 kPa (138 psi)	717 kPa (104 psi)	1158 kPa (168 psi)	869 kPa (126 psi)	1365 kPa (198 psi)	1020 kPa (148 psi)	1572 kPa (228 psi)	1179 kPa (171 psi)
965 kPa (140 psi)	724 kPa (106 psi)	1172 kPa (170 psi)	876 kPa (127 psi)	1379 kPa (200 psi)	1034 kPa (150 psi)	1586 kPa (230 psi)	1186 kPa (172 psi)
979 kPa (142 psi)	738 kPa (107 psi)	1186 kPa (172 psi)	889 kPa (129 psi)	1303 kPa (202 psi)	1041 kPa (151 psi)	1600 kPa (232 psi)	1200 kPa (174 psi)
933 kPa (144 psi)	745 kPa (109 psi)	1200 kPa (174 psi)	903 kPa (131 psi)	1407 kPa (204 psi)	1055 kPa (153 psi)	1055 kPa (153 psi)	1207 kPa (175 psi)
1007 kPa (146 psi)	758 kPa (110 psi)	1214 kPa (176 psi)	910 kPa (132 psi)	1420 kPa (206 psi)	1062 kPa (154 psi)	1627 kPa (154 psi)	1220 kPa (177 psi)

DIAGNOSIS AND TESTING (Continued)

Compression Pressure Limit Chart (Continued)

Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure	Maximum Pressure	Minimum Pressure
1020 kPa (148 psi)	765 kPa (111 psi)	1227 kPa (178 psi)	917 kPa (133 psi)	1434 kPa (208 psi)	1075 kPa (156 psi)	1641 kPa (238 psi)	1227 kPa (178 psi)
1034 kPa (150 psi)	779 kPa (113 psi)	1241 kPa (180 psi)	931 kPa (135 psi)	1448 kPa (210 psi)	1083 kPa (157 psi)	1655 kPa (240 psi)	1241 kPa (180 psi)
1048 kPa (152 psi)	786 kPa (114 psi)	1255 kPa (182 psi)	936 kPa (136 psi)	1462 kPa (212 psi)	1089 kPa (158 psi)	1669 kPa (242 psi)	1248 kPa (181 psi)
1062 kPa (154 psi)	793 kPa (115 psi)	1269 kPa (184 psi)	952 kPa (138 psi)	1476 kPa (214 psi)	1103 kPa (160 psi)	1682 kPa (244 psi)	1262 kPa (183 psi)
1076 kPa (156 psi)	807 kPa (117 psi)	1282 kPa (186 psi)	965 kPa (140 psi)	1489 kPa (216 psi)	1117 kPa (162 psi)	1696 kPa (246 psi)	1269 kPa (184 psi)
1089 kPa (158 psi)	814 kPa (118 psi)	1296 kPa (188 psi)	972 kPa (141 psi)	1503 kPa (218 psi)	1124 kPa (163 psi)	1710 kPa (248 psi)	1202 kPa (186 psi)
1103 kPa (160 psi)	827 kPa (120 psi)	1310 kPa (190 psi)	979 kPa (142 psi)	1517 kPa (220 psi)	1138 kPa (165 psi)	1724 kPa (250 psi)	1289 kPa (187 psi)
1110 kPa (161 psi)	834 kPa (121 psi)	1324 kPa (192 psi)	993 kPa (144 psi)	1631 kPa (222 psi)	1145 kPa (166 psi)	—	—

If one or more cylinders reads low, squirt approximately one tablespoon of engine oil on top of the pistons in the low-reading cylinders. Repeat the compression pressure check on these cylinders.

Compression Test — Interpreting Compression Readings

1. If compression improves considerably, piston rings are faulty.
2. If compression does not improve, valves are sticking or seating incorrectly.
3. If 2 adjacent cylinders indicate low compression pressures and squirting oil on each piston does not increase compression, the head gasket may be leaking between cylinders. Engine oil or coolant in cylinders could result from this condition.

   Use the Compression Pressure Limit Chart when checking cylinder compression so that the lowest reading is at least 75 percent of the highest reading.

Cylinder Leakage Detection

When a cylinder produces a low reading, use of the Engine Cylinder Leak Detection/Air Pressurization Kit will be helpful in pinpointing the exact cause.

The leakage detector is inserted in the spark plug hole, the piston is brought up to dead center on the compression stroke, and compressed air is admitted. Once the combustion chamber is pressurized, a special gauge included in the kit will read the percentage of leakage. Leakage exceeding 20 percent is excessive.

While the air pressure is retained in the cylinder, listen for the hiss of escaping air. A leak at the intake valve will be heard in the throttle body. A leak at the exhaust valve can be heard at the tail pipe. Leakage past the piston rings will be audible at the positive crankcase ventilation (PCV) connection. If air is passing through a blown head gasket to an adjacent cylinder, the noise will be evident at the spark plug hole of the cylinder into which the air is leaking. Cracks in the cylinder block or gasket leakage into the cooling system may be detected by a stream of bubbles in the radiator.

Intake Manifold Vacuum Test

Bring the engine to normal operating temperature. Connect the Vacuum/Pressure Tester to the intake manifold. Run the engine at the specified idle speed.

The vacuum gauge should read between 51-74 kPa (15-22 in-Hg), depending upon the engine condition and the altitude at which the test is performed. Subtract 4.0193 kPa (1 in-Hg) from the specified reading for every 304.8 m (1,000 feet) of elevation above sea level.

The reading should be steady. If necessary, adjust the gauge damper control (where used) if the needle is fluttering rapidly. Adjust the damper until the needle moves easily without excessive flutter.

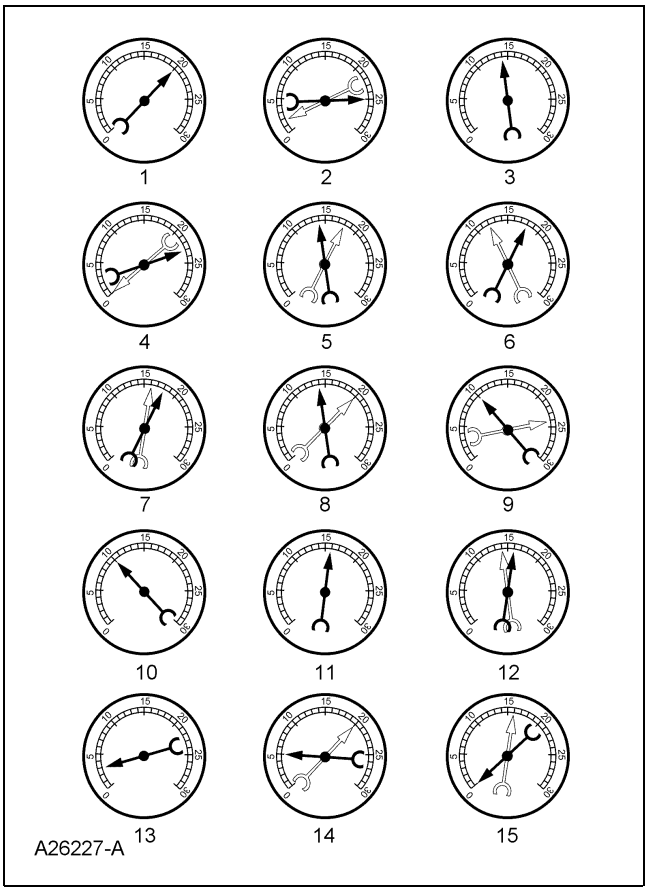
DIAGNOSIS AND TESTING (Continued)

Intake Manifold Vacuum Test — Interpreting Vacuum Gauge Readings

A careful study of the vacuum gauge reading while the engine is idling will help pinpoint trouble areas. Always conduct other appropriate tests before arriving at a final diagnostic decision. Vacuum gauge readings, although helpful, must be interpreted carefully.

Most vacuum gauges have a normal band indicated on the gauge face.

The following are potential gauge readings. Some are normal; others should be investigated further.



1. NORMAL READING: Needle between 51-74 kPa (15-22 in-Hg) and holding steady.
2. NORMAL READING DURING RAPID ACCELERATION AND DECELERATION: When the engine is rapidly accelerated (dotted needle), the needle will drop to a low reading (not to zero). When the throttle is suddenly released, the needle will snap back up to a higher than normal figure.
3. NORMAL FOR HIGH-LIFT CAMSHAFT WITH LARGE OVERLAP: The needle will register as low as 51 kPa (15 in-Hg) but will be relatively steady. Some oscillation is normal.
4. WORN RINGS OR DILUTED OIL: When the engine is accelerated (dotted needle), the needle drops to 0 kPa (0 in-Hg). Upon deceleration, the needle runs slightly above 74 kPa (22 in-Hg).
5. STICKING VALVES: When the needle (dotted) remains steady at a normal vacuum but occasionally flicks (sharp, fast movement) down and back about 13 kPa (4 in-Hg), one or more valves may be sticking.
6. BURNED OR WARPED VALVES: A regular, evenly-spaced, downscale flicking of the needle indicates one or more burned or warped valves. Insufficient hydraulic lash adjuster (HLA) or HLA clearance will also cause this reaction.
7. POOR VALVE SEATING: A small but regular downscale flicking can mean one or more valves are not seating.
8. WORN VALVE GUIDES: When the needle oscillates over about a 13 kPa (4 in-Hg) range at idle speed, the valve guides could be worn. As engine speed increases, the needle will become steady if guides are responsible.
9. WEAK VALVE SPRINGS: When the needle oscillation becomes more violent as engine rpm is increased, weak valve springs are indicated. The reading at idle could be relatively steady.
10. LATE VALVE TIMING: A steady but low reading could be caused by late valve timing.
11. IGNITION TIMING RETARDING: Retarded ignition timing will produce a steady but somewhat low reading.
12. INSUFFICIENT SPARK PLUG GAP: When spark plugs are gapped too close, a regular, small pulsation of the needle can occur.
13. INTAKE LEAK: A low, steady reading can be caused by an intake manifold or throttle body gasket leak.
14. BLOWN HEAD GASKET: A regular drop of fair magnitude can be caused by a blown head gasket or warped cylinder head-to-cylinder block surface.

DIAGNOSIS AND TESTING (Continued)

15. RESTRICTED EXHAUST SYSTEM: When the engine is first started and is idled, the reading may be normal, but as the engine rpm is increased, the back pressure caused by a clogged muffler, kinked tail pipe or other concerns will cause the needle to slowly drop to 0 kPa (0 in-Hg). The needle then may slowly rise. Excessive exhaust clogging will cause the needle to drop to a low point even if the engine is only idling.
16. When vacuum leaks are indicated, search out and correct the cause. Excess air leaking into the system will upset the fuel mixture and cause concerns such as rough idle, missing on acceleration or burned valves. If the leak exists in an accessory unit such as the power brake booster, the unit will not function correctly. Always fix vacuum leaks.

Excessive Engine Oil Consumption

Nearly all engines consume oil, which is essential for normal lubrication of the cylinder bore walls and pistons and rings. Determining the level of oil consumption may require testing by recording how much oil is being added over a given set of miles.

Customer driving habits greatly influence oil consumption. Mileage accumulated during towing or heavy loading generates extra heat. Frequent short trips, stop-and-go type traffic or extensive idling, prevent the engine from reaching normal operating temperature. This prevents component clearances from reaching specified operating ranges.

The following diagnostic procedure may be utilized to determine internal oil consumption. Make sure that the concern is related to internal oil consumption, and not external leakage, which also consumes oil. Verify there are no leaks before carrying out the test. Once verified, the rate of internal oil consumption can be tested.

A new engine may require extra oil in the early stages of operation. Internal piston-to-bore clearances and sealing characteristics improve as the engine breaks in. Engines are designed for close tolerances and do not require break-in oils or additives. Use the oil specified in the owner guide. Ambient temperatures may determine the oil viscosity specification. Verify that the correct oil is being used for the vehicle in the geographic region in which it is driven.

Basic Pre-checks

1. For persistent complaints of oil consumption, interview the customer to determine the oil consumption characteristics. If possible, determine the brand and grade of oil currently in the oil pan. Look at the oil filter or oil-change station tags to determine if Ford-recommended maintenance schedules have been followed. Make sure that the oil has been changed at the specified mileage intervals. If vehicle mileage is past the first recommended drain interval, the OEM production filter should have been changed.
2. Ask how the most current mileage was accumulated. That is, determine whether the vehicle was driven under the following conditions:
   - Extended idling or curbside engine operation
   - Stop-and-go traffic or taxi operation
   - Towing a trailer or vehicle loaded heavily
   - Frequent short trips (engine not up to normal operating temperature)
   - Excessive throttling or high engine-rpm driving
3. Verify that there are no external leaks. If necessary, review the diagnostic procedure under Engine Oil Leaks in the Diagnosis and Testing portion of this section.
4. Inspect the crankcase ventilation system for:
   - disconnected hoses at the valve cover or throttle body.
   - loose or missing valve cover fill cap.
   - missing or incorrectly seated engine oil level indicator.
   - incorrect or dirty PCV valve.
   - a PCV valve grommet unseated in the valve cover (if so equipped)
5. Inspect for signs of sludge. Sludge affects PCV performance and can plug or restrict cylinder head drainback wells. It can also increase oil pressure by restricting passages and reducing the drainback capability of piston oil control rings. Sludge can result from either excessive water ingestion in the crankcase or operation at extremely high crankcase temperatures.

DIAGNOSIS AND TESTING (Continued)

6. Inspect the air filter for dirt, sludge or damage. A hole in the filter element will allow unfiltered air to bypass into the air induction system. This can cause premature internal wear (engine dusting), allowing oil to escape past rings, pistons, valves and guides.
7. If the engine is hot or was recently shut down, wait at least 5 minutes to allow the oil to drain back. Ask the customer if this requirement has been followed. Adding oil without this wait period can cause an overfill condition, leading to excessive oil consumption and foaming which may cause engine damage.
8. Make sure the oil level indicator (dipstick) is correctly and fully seated in the indicator tube. Remove the oil level indicator and record the oil level.

Detailed Pre-checks

1. Check the thermostat opening temperature to make sure that the cooling system is operating at the specified temperature. If it is low, internal engine parts are not running at specified internal operating clearances.
2. Verify the spark plugs are not oil saturated. Oil leaking into one or more cylinders will appear as an oil soaked condition on the plug. If a plug is saturated, a compression check may be necessary at the conclusion of the oil consumption test.

Oil Consumption Test

Once all of the previous conditions are met, carry out an oil consumption test.

1. Drain the engine oil and remove the oil filter. Install a new manufacturer-specified oil filter. Make sure the vehicle is positioned on a level surface. Refill the oil pan to a level **one quart (liter) less** than the specified fill level, using manufacturer-specified oil.
2. Run the engine for 3 minutes (if hot) or 10 minutes (if cold). Allow for a minimum 5-minute drainback period and then record the oil level shown on the oil level indicator. Place a mark on the backside of the oil level indicator noting the oil level location.
3. Add the final 1 quart (liter) to complete the normal oil fill. Restart the engine and allow it to idle for 2 minutes. Shut the engine down.
4. After a 5-minute drainback period, record the location of the oil level again. Mark the oil level indicator with the new oil level location. (Note: Both marks should be very close to the MIN-MAX upper and lower limits or the upper and lower holes on the oil level indicator. These marks will exactly measure the engine's use of oil, with a one quart differential between the new marks.) Demonstrate to the customer that the factory-calibrated marks on the dipstick are where the oil should fall after an oil change with the specified fill amount. Explain however, that this may vary slightly between MIN-MAX or the upper and lower holes on the oil level indicator.
5. Record the vehicle mileage.
6. Advise the customer that oil level indicator readings must be taken every 320 km (200 miles) or weekly, using the revised marks as drawn. Remind the customer that the engine needs a minimum 5-minute drainback for an accurate reading and that the oil level indicator must be firmly seated in the tube prior to taking the reading.
7. When the subsequent indicator readings demonstrate a full quart (liter) has been used, record the vehicle mileage. The mileage driven between the 2 readings should not be less than 1,500 miles. The drive cycle the vehicle has been operated under must be considered when making this calculation. It may be necessary to have the customer bring the vehicle in for a periodic oil level indicator reading to closely monitor oil usage.

Post Checks, Evaluation and Corrective Action

1. If test results indicate excessive oil consumption, carry out a cylinder compression test. The cylinder compression test should be carried out with a fully charged battery and all spark plugs removed. See the Compression Test Chart in this section for pressure range limits.
2. Compression should be consistent across all cylinders. For additional information, refer to the Compression Testing portion of this section. If compression tested within the specifications found in this section, the excessive oil consumption may be due to wear on the valve guides, valves or valve seals.

DIAGNOSIS AND TESTING (Continued)

3. A cylinder leak detection test can be carried out using an Engine Cylinder Leak Detection/Air Pressurization Kit. This can help identify valves, piston rings, or worn valve guides/valve stems, inoperative valve stem seals or other related areas as the source of oil consumption.

NOTE: An oil-soaked appearance on the porcelain tips of the spark plugs also indicates excessive oil use. A typical engine with normal oil consumption will exhibit a light tan to brown appearance. See Spark Plug Analysis in this section for details. A single or adjoining, multiple cylinder leak can be traced by viewing the tips.

4. If an internal engine part is isolated as the root cause, determine if the repair will exceed cost limits and proceed with a repair strategy as required.
5. Once corrective action to engine is complete and verifying that all pre-check items were eliminated in the original diagnosis, repeat the Oil Consumption Test as described above and verify consumption results.

Oil Pressure Test

1. Disconnect and remove the oil pressure sensor from the engine.
2. Connect the Oil Pressure Gauge to the oil pressure sender oil galley port.
3. Run the engine until normal operating temperature is reached.
4. Run the engine at the specified rpm and record the gauge reading.
5. The oil pressure should be within specifications; refer to the specification chart in the appropriate engine section.
6. If the pressure is not within specification, check the following possible sources:
   - Insufficient oil
   - Oil leakage
   - Worn or damaged oil pump
   - Oil pump screen cover and tube
   - Excessive main bearing clearance
   - Excessive connecting rod bearing clearance

Valve Train Analysis — Engine Off — Valve Cover Removed

Check for damaged or severely worn parts and correct assembly. Make sure correct parts are used with the static engine analysis as follows.

Valve Train Analysis — Engine Off, Rocker Arm

- Check for loose mounting bolts, studs and nuts.
- Check for plugged oil feed in the rocker arms or cylinder head.

Valve Train Analysis — Engine Off, Camshaft Roller Followers and Hydraulic Lash Adjusters, Overhead Camshaft

- Check for loose mounting bolts on camshaft carriers.
- Check for plugged oil feed in the camshaft roller followers, lash adjusters or cylinder heads.

Valve Train Analysis — Engine Off, Camshaft — Engines

- Check for broken or damaged parts.

Valve Train Analysis — Valve Springs

- Check for broken or damaged parts.

Valve Train Analysis — Engine Off, Valve Spring Retainer and Valve Spring Retainer Keys

- Check for correct seating of the valve spring retainer key on the valve stem and in valve spring retainer.
- Check for correct seating on the valve stem.

Valve Train Analysis — Engine Off, Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for worn or damaged valve tips.
- Check for missing or damaged guide-mounted valve stem seal.
- Check collapsed valve tappet gap.
- Check installed valve spring height.
- Check for missing or worn valve spring seats.
- Check for plugged oil metering orifice in cylinder head oil reservoir (if equipped).

Static checks (engine off) are to be made on the engine prior to the dynamic procedure.

DIAGNOSIS AND TESTING (Continued)

Valve Train Analysis — Engine Running

- Start the engine and, while idling, check for correct operation of all parts. Check the following:

Valve Train Analysis — Engine Running, Valves and Cylinder Head

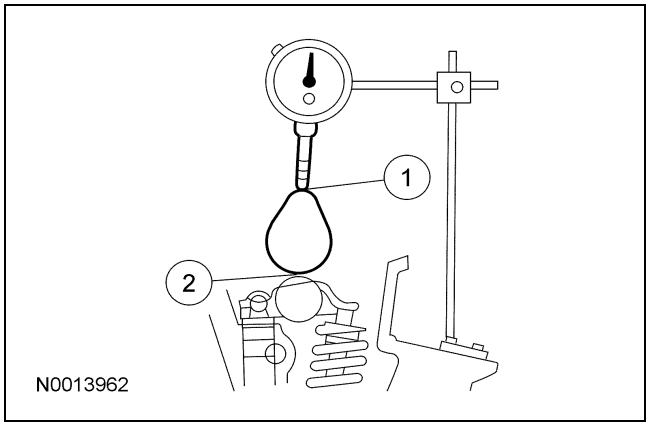
- Check for plugged oil drain back holes.
- Check for missing or damaged valve stem seals or guide-mounted valve stem seals.
- Check for a plugged oil metering orifice for thrust groove oil supply in the cylinder head thrust cap (4.6L engine only).

If insufficient oiling is suspected, check oil passages for blockage, then accelerate the engine to 1,200 rpm with the transmission in NEUTRAL and the engine at normal operating temperature. Oil should spurt from the rocker arm oil holes such that valve tips and camshaft roller followers are well oiled. With the valve covers off, some oil splash may overshoot camshaft roller followers.

Valve Train Analysis — Engine Running, Camshaft Lobe Lift — OHC Engines

Check the lift of each camshaft lobe in consecutive order and make a note of the readings.

1. Remove the valve covers.
2. Remove the spark plugs.
3. Install the Dial Indicator Gauge with Holding Fixture so the rounded tip of indicator is on top of the camshaft lobe and on the same plane as the valve tappet.
4. Rotate the crankshaft using a breaker bar and socket attached to the crankshaft pulley retainer bolt. Rotate the crankshaft until the base circle of the camshaft lobe is reached.



5. Zero the dial indicator. Continue to rotate the crankshaft until the (1) high-lift point of the camshaft lobe is in the fully-raised position (highest indicator reading).
6. To check the accuracy of the original indicator reading, continue to rotate crankshaft until the (2) base circle is reached. The indicator reading should be zero. If zero reading is not obtained, repeat Steps 1 through 6.
7. **NOTE:** If the lift on any lobe is below specified service limits, install a new camshaft, and new camshaft roller followers.

   Remove the Dial Indicator Gauge with Holding Fixture.
8. Install the spark plugs.
9. Install the valve covers.

Valve Train Analysis — Engine Running, Valve Tappet

Valve tappet noise can be caused by any of the following:

- Excessive valve tappet gap (collapsed)
- Incorrectly functioning valve tappet
- Air in lubrication system
- Excessive valve guide wear
- Low oil pressure

Excessive collapsed valve tappet gap can be caused by loose rocker arm seat bolts/nuts, incorrect initial adjustment or wear of valve tappet face, or worn roller valve tappets, push rod, rocker arm, rocker arm seat or valve tip. With valve tappet collapsed, check gap between the valve tip and the rocker arm to determine if any other valve train parts are damaged, worn or out of adjustment.

An incorrectly functioning valve tappet can be sticking, caused by contaminants or varnish inside the tappet. The tappet can have a check valve that is not functioning correctly, which can be caused by an obstruction, such as dirt or chips that prevent the check valve from closing, or a broken check valve spring. A tappet with a leakdown time out of specification can cause tappet noise. If no other cause for noisy valve tappets can be found, the leakdown rate should be checked and new valve tappets installed if found to be out of specification.

DIAGNOSIS AND TESTING (Continued)

Assembled valve tappets can be tested with Hydraulic Lash Adjuster Leakdown Tester to check the leakdown rate. The leakdown rate specification is the time in seconds for the plunger to move a specified distance while under a 22.7 kg (50 lb) load.

Air bubbles in the lubrication system will prevent the valve tappet from supporting the valve spring load. This can be caused by too high or too low an oil level in the oil pan or by air being drawn into the system through a hole, crack or leaking gasket on the oil pump screen cover and tube.