SPECIFICATIONS

MATERIAL SPECIFICATION

MATERIAL SPECIFICATION

Item	Specification	Fill Capacity
Dye-Lite® Gasoline Engine Oil Leak Detection Dye 164-R3700 (Rotunda)	-	-
LOCTITE® Retaining Compound 620 High Temperature Loctite 620/Permatex 62050	WSK-N2G349-A9	-
Motorcraft SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP (US); Motorcraft SAE 5W-20 Super Premium Motor Oil CXO-5W20-LSP12 (Canada); or equivalent	WSS-M2C930-A	-
Motorcraft SAE 5W-30 Premium Synthetic Blend Motor Oil XO-5W30-QSP (US); Motorcraft SAE 5W-30 Super Premium Motor Oil CXO-5W30-LSP12 (Canada); or equivalent	WSS-M2C929-A	-
Threadlock 262 TA-26	WSK-M2G351-A6	-

DESCRIPTION AND OPERATION

ENGINE

NOTE: When repairing engines, all parts must be contamination free. If contamination/foreign material is present when repairing an engine, premature engine failure may occur.

NOTE: This service information contains information, steps and procedures that may not be specific to your engine.

NOTE: If a component fails to meet the specifications, repair or install a new component as necessary.

NOTE: Refer to the ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

This information covers general procedures and diagnosis and testing of the engine system, except for exhaust emission control devices, the diagnosis of which are covered in the **INTRODUCTION - GASOLINE MODELS** .

The engine incorporates the following features:

- a closed PCV system. For service, refer to **ENGINE EMISSION CONTROL** .
- an exhaust emission control system. For service, refer to **ENGINE EMISSION CONTROL** .

- an evaporative emission (EVAP) control system. For service, refer to **EVAPORATIVE EMISSIONS** .

Some engines incorporate a fail-safe cooling system. Refer to the **ENGINE COOLING** for the procedure.

The engine, fuel system, ignition system, emissions system and exhaust system all affect exhaust emission levels and must be maintained according to the maintenance schedule. Refer to the scheduled Maintenance Guide.

Correct engine identification is required to order parts. Refer to appropriate Engine article

For complete vehicle and engine identification codes, refer to **IDENTIFICATION CODES** .

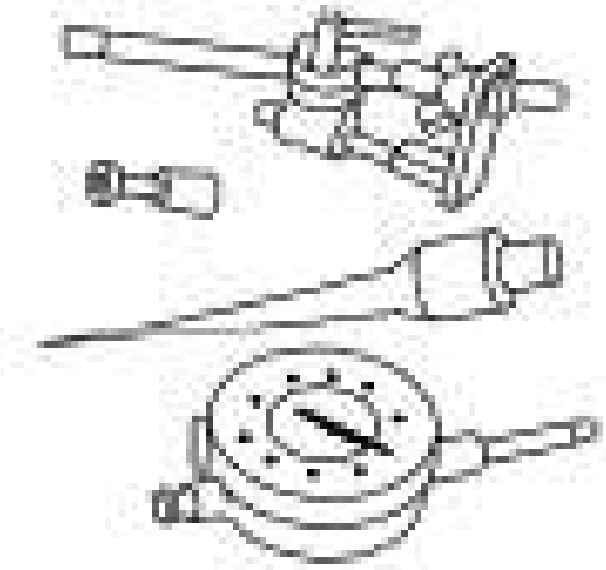
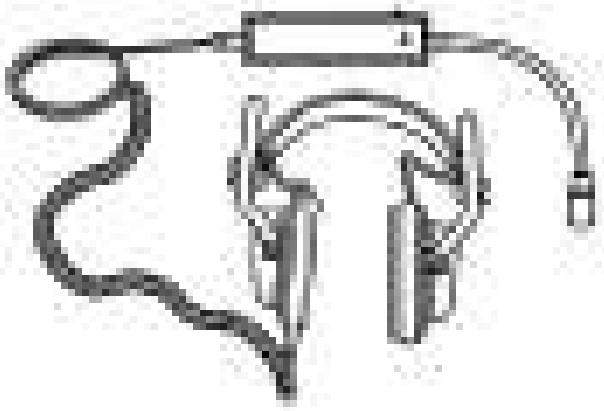
DIAGNOSIS AND TESTING

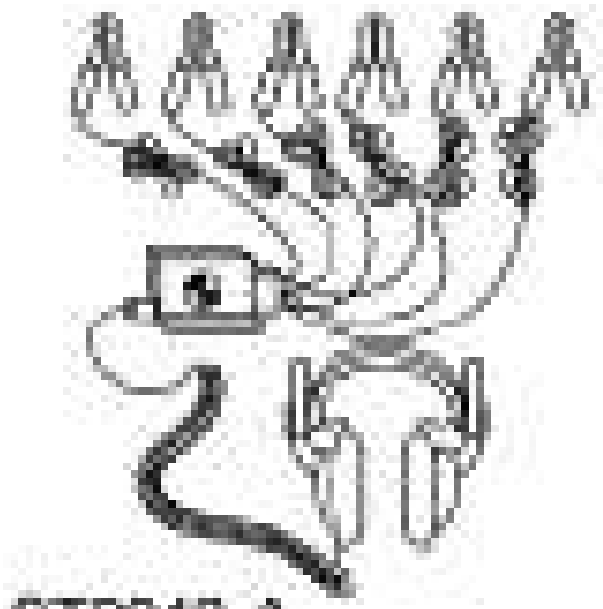
ENGINE

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	12 Volt Master UV Diagnostic Inspection Kit 164-R0756 or equivalent (Leak Detector)

 ST1214-A	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent
 ST2312-A	EngineEAR 107-R2103 or equivalent
	EngineEAR/ChassisEAR 107-R2102 or equivalent

 ST2048-A	
 ST1296-A	Oil Pressure Gauge 303-088 (T73L-6600-A)
	Ultrasonic Leak Detector 134-R0135 or equivalent

	
	Vacuum/Pressure Tester 164-R0253 or equivalent
	Vehicle Communication Module (VCM) and Integrated Diagnostic System (IDS) software

	with appropriate hardware, or equivalent scan tool

Material

MATERIAL SPECIFICATION

Item	Specification
Dye-Lite® Gasoline Engine Oil Leak Detection Dye 164-R3700 (Rotunda)	-
Motorcraft® SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP (US); Motorcraft® SAE 5W-20 Super Premium Motor Oil CXO-5W20-LSP12 (Canada); or equivalent	WSS-M2C930-A
Motorcraft® SAE 5W-30 Premium Synthetic Blend Motor Oil XO-5W30-QSP (US); Motorcraft® SAE 5W-30 Super Premium Motor Oil CXO-5W30-LSP12 (Canada); or equivalent	WSS-M2C929-A

There are 2 diagnostic paths that can be followed depending on the type of engine concern. Carry out **INSPECTION AND VERIFICATION - Engine Performance** or **INSPECTION AND VERIFICATION - NVH**.

Inspection and Verification - Engine Performance

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. **NOTE: Make sure to use the latest scan tool software release.**

   If the cause is not visually evident, connect the scan tool to the Data Link Connector (DLC).

5. **NOTE: The Vehicle Communication Module (VCM) LED prove out confirms power and ground from the DLC are provided to the VCM .**

   If the scan tool does not communicate with the **VCM** :

   - check the **VCM** connection to the vehicle.
   - check the scan tool connection to the **VCM** .
   - refer to **MODULE COMMUNICATIONS NETWORK** , No Power To The Scan Tool, to diagnose no power to the scan tool.
6. If the scan tool does not communicate with the vehicle:
   - verify the ignition key is in the ON position.
   - verify the scan tool operation with a known good vehicle.
   - refer to **MODULE COMMUNICATIONS NETWORK** to diagnose no response from the PCM.
7. Carry out the network test.
   - If the scan tool responds with no communication for one or more modules, refer to **MODULE COMMUNICATIONS NETWORK** .
   - If the network test passes, retrieve and record Continuous Memory Diagnostic Trouble Codes (CMDTCs).
8. Clear the **CMDTCs** and carry out the self-test diagnostics for the PCM.
9. If the DTCs retrieved are related to the concern, refer to **MULTIFUNCTION ELECTRONIC MODULES** .
10. If no DTCs related to the concern are retrieved, GO to **SYMPTOM CHART - ENGINE PERFORMANCE**.

Inspection and Verification - NVH

1. NVH symptoms should be identified using the diagnostic tools and techniques that are available. For a list of these techniques, tools, an explanation of their uses and a glossary of common terms, refer to **NOISE, VIBRATION AND HARSHNESS** .
2. Verify the customer concern by operating the engine to duplicate the condition.
3. Check the engine oil level and check the oil for contamination. Low engine oil level or contaminated oil are a common cause of engine noise. If the oil is contaminated the source of the contamination must be identified and repair as necessary.
4. Visually inspect for obvious signs of mechanical damage. Refer to the following chart.

VISUAL INSPECTION CHART

Mechanical
• Loose mounting bolts, studs and nuts • Damaged or leaking powertrain mounts

- Damaged or disconnected vacuum hoses
- Obstruction of cooling fan
- Obstruction of Front End Accessory Drive (FEAD)
- Obstruction of Rear End Accessory Drive (READ), if equipped
- Damaged or disconnected air intake components

5. If the inspection reveals obvious concerns that can be readily identified, repair as necessary.
6. **NOTE: Make sure to use the latest scan tool software release.**

   If the cause is not visually evident, connect the scan tool to the Data Link Connector (DLC).

7. **NOTE: The Vehicle Communication Module (VCM) LED prove out confirms power and ground from the DLC are provided to the VCM .**

   If the scan tool does not communicate with the **VCM** :

   - check the **VCM** connection to the vehicle.
   - check the scan tool connection to the **VCM** .
   - refer to **MODULE COMMUNICATIONS NETWORK** , No Power To The Scan Tool, to diagnose no power to the scan tool.
8. If the scan tool does not communicate with the vehicle:
   - verify the ignition key is in the ON position.
   - verify the scan tool operation with a known good vehicle.
   - refer to **MODULE COMMUNICATIONS NETWORK** to diagnose no response from the PCM.
9. Carry out the network test.
   - If the scan tool responds with no communication for one or more modules, refer to **MODULE COMMUNICATIONS NETWORK** .
   - If the network test passes, retrieve and record Continuous Memory Diagnostic Trouble Codes (CMDTCs).
10. Clear the **CMDTCs** and carry out the self-test diagnostics for the PCM.
11. If the DTCs retrieved are related to the concern, refer to **MULTIFUNCTION ELECTRONIC MODULES** .
12. If no DTCs related to the concern are retrieved, continue the inspection and verification if a noise concern is related to the engine. For vibration concerns and noise concerns such as powertrain mounts, air intake system and starter, GO to **SYMPTOM CHART - NVH**.

In some cases, a noise may be a normal characteristic of that engine type. In other cases the noise may require further investigation. Comparing the noise to a similar year/model vehicle equipped with the same engine will aid in determining if the noise is normal or abnormal.

Once a customer concern has been identified as an abnormal engine noise, it is critical to determine the location of the specific noise. Use the EngineEAR/ChassisEAR or stethoscope (the noise will always be louder the closer you get to the noise source) to isolate the location of the noise to one of the following areas.

- Fuel injector(s)
- Upper end of engine
- Lower end of engine
- Front of engine
- Rear of engine

Fuel injector noise

A common source of an engine ticking noise can be related to the fuel injector(s). This is normal engine noise that can be verified by listening to another vehicle. If the injector noise is excessive or irregular, use the EngineEAR/ChassisEAR or stethoscope to isolate the noise to a specific fuel injector.

Upper end engine noise

A common source of upper end engine noise (ticking, knocking or rattle) includes the camshaft(s) and valve train. Upper end engine noise can be determined using the EngineEAR/ChassisEAR or stethoscope on the valve cover bolts. If the noise is loudest from the valve cover bolts, then the noise is upper end. The EngineEAR/ChassisEAR or stethoscope can be used to further isolate the noise to the specific cylinder bank and cylinder. Removal of the valve covers will be required to pinpoint the source of the noise.

Lower end engine noise

A common source of lower end engine noise (ticking or knocking) includes the crankshaft, connecting rod (s) and bearings. Lower end noises can be determined by using the oil pan or cylinder block lug bosses. If the noise is loudest from these areas then the noise is lower end. If an engine noise is isolated to the lower end, some disassembly of the engine may be required to inspect for damage or wear.

Front of engine noise

A common source of noise from the front of the engine (squeal, chirp, whine or hoot) is the Front End Accessory Drive (FEAD) components. To isolate **FEAD** noise, carry out the Engine Accessory Test. Refer to **NOISE, VIBRATION AND HARSHNESS** .

Some other noises from the front of the engine (ticking, tapping or rattle) may be internal to the engine. Use the EngineEAR/ChassisEAR or stethoscope on the engine front cover to determine if the noise is internal to the engine. Removal of the engine front cover may be necessary to inspect internal engine components.

Rear of engine noise

A common source of noise from the rear of the engine (knocking) is the flywheel/flexplate. Inspection of the flywheel/flexplate will be necessary.

13. After you have localized the noise, note the characteristics of the noise, including type of noise, frequency and conditions when the noise occurs and GO to **SYMPTOM CHART - NVH**.

Symptom Chart - Engine Performance

SYMPTOM CHART - ENGINE PERFORMANCE

Condition	Possible Sources	Action
		• Refer to the appropriate Engine article for

• Difficult starting	• Damaged ignition system	the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Damaged fuel system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Damaged starting system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Damaged charging system/battery	• REFER to **CHARGING SYSTEM** .
	• Burnt valve	• INSTALL a new valve.
	• Worn piston	• For 2.3L engines, INSTALL a new piston and piston pin. For 4.0L engines, INSTALL a new short block.
	• Worn piston rings	• For 2.3L engines, INSTALL new piston rings. For 4.0L engines, INSTALL a new short block.
	• Worn cylinder	• For 2.3L engines, INSTALL a new cylinder block. For 4.0L engines, INSTALL a new short block.
	• Damaged head gasket	• INSTALL a new head gasket.
	• Damaged cooling system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
• Poor idling	• Vacuum leaks	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Malfunctioning or damaged ignition system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Malfunctioning or damaged fuel system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Damaged lash adjuster	• INSTALL a new lash adjuster.
	• Incorrect valve-to-valve seat contact	• REPAIR or INSTALL a new valve or valve seat.
	• Damaged head gasket	• INSTALL a new head gasket.
	• Worn or damaged	• INSTALL new engine support brackets.

	engine support brackets • Worn or damaged engine support insulators • Worn or damaged transmission insulator and retainer	 • 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 lash adjuster • Burnt or sticking valve • Weak or broken valve spring • Carbon accumulation in combustion chamber	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** . • Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** . • Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** . • INSTALL a new lash adjuster. • 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 2.3L engines, INSTALL new piston rings. For 4.0L engines, INSTALL a new short block. • For 2.3L engines, INSTALL a new piston. For 4.0L engines, INSTALL a new short block. • For 2.3L engines, INSTALL a new cylinder block. For 4.0L engines, INSTALL a new short block.
• Engine noise	• Leaking exhaust system • Incorrect drive belt tension	• REPAIR exhaust leakage. • REFER to **ACCESSORY DRIVE** .

	• Malfunctioning generator bearing	• Refer to the appropriate Engine article for the procedure.
	• Malfunctioning water pump bearing	• REFER to **ENGINE COOLING** .
	• Malfunctioning or damaged cooling system	• REFER to **ENGINE COOLING** .
	• Malfunctioning or damaged fuel system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• 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	• For 2.3L engines, INSTALL a new crankshaft main bearing. For 4.0L engines, INSTALL a new short block.
	• Seized or heat damaged crankshaft main bearing	• For 2.3L engines, INSTALL a new crankshaft main bearing. For 4.0L engines, INSTALL a new short block. CHECK the cylinder head distortion.
	• Excessive crankshaft end play	• For 2.3L engines, INSTALL a new thrust bearing or crankshaft. For 4.0L engines, INSTALL a new short block.
	• Excessive connecting rod bearing clearance	• For 2.3L engines, INSTALL a new connecting rod bearing or connecting rod. For 4.0L engines, INSTALL a new short block.
	• Heat damaged connecting rod bearing	• For 2.3L engines, INSTALL a new connecting rod bearing or connecting rod. For 4.0L engines, INSTALL a new short block.
	• Damaged connecting rod bushing	• For 2.3L engines, INSTALL a new connecting rod bushing. For 4.0L engines, INSTALL a new short block.
	• Worn cylinder	• For 2.3L engines, INSTALL new cylinder block. For 4.0L engines, INSTALL a new short block.
	• Worn piston or piston pin	• For 2.3L engines, INSTALL new piston or piston pin. For 4.0L engines, INSTALL a new short block.
	• Damaged piston rings	• For 2.3L engines, INSTALL new piston rings. For 4.0L engines, INSTALL a new short block.
		• For 2.3L engines, INSTALL a new

	• Bent connecting rod	connecting rod. For 4.0L engines, INSTALL a new short block.
	• 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 and stem.
• Insufficient power	• Malfunctioning or damaged ignition system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Malfunctioning or damaged fuel system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Malfunctioning or damaged air intake system	• Refer to the appropriate Engine article for the procedure. REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• Damaged or plugged exhaust system	• INSPECT exhaust system.
	• Incorrect tire size	• REFER to **WHEELS & TIRES** .
	• Dragging brakes	• REFER to **BRAKE SYSTEM - GENERAL INFORMATION** .
	• Slipping transmission	• Refer to the appropriate Automatic Transmission article for the procedure.
	• Malfunctioning valve tappet or lash adjuster	• INSTALL a new valve tappet or lash adjuster.
	• Damaged valve tappet guide, valve tappet or lash adjuster guide	• For 2.3L engines, INSTALL a new valve tappet guide or valve tappet. For 4.0L SOHC engines, INSTALL a new cylinder head.
	• Compression leakage at valve seat	• For 2.3L engines, REPAIR or INSTALL a new valve, valve seat or cylinder head. For 4.0L SOHC engines, INSTALL a new cylinder head.
	• Seized valve stem	• For 2.3L engines, INSTALL a new valve. For 4.0L SOHC engines, INSTALL a new cylinder head.
	• Weak or broken valve spring	• INSTALL a new valve spring.
		• For 2.3L engines, INSTALL a new

	• Worn or damaged cam • Damaged head gasket • Cracked or distorted cylinder head • Damaged, worn or sticking piston ring(s) • Worn or damaged piston	camshaft. For 4.0L SOHC engines, INSTALL a new cylinder head. • INSTALL a new head gasket. • INSTALL a new cylinder head. • For 2.3L engines, INSTALL new piston rings. For 4.0L engines, INSTALL a new short block. • For 2.3L engines, INSTALL a new piston or piston pin. For 4.0L engines, INSTALL a new short block.

Symptom Chart - NVH

NOTE: NVH symptoms should be identified using the diagnostic tools that are available. For a list of these tools, an explanation of their uses and a glossary of common terms, refer to NOISE, VIBRATION AND HARSHNESS . Since it is possible that any one of multiple systems may be the cause of the symptom, it may be necessary to use a process of elimination type of diagnostic approach to pinpoint the responsible system. If this is not the causal system for the symptom, refer back to NOISE, VIBRATION AND HARSHNESS for the next likely system and continue diagnosis.

SYMPTOM CHART - NVH

Condition	Possible Sources	Action
• Drone type noise	• Powertrain mount (s)	• CARRY OUT the **POWERTRAIN/DRIVETRAIN MOUNT NEUTRALIZING** procedure.
• Drumming noise - occurs inside the vehicle during idle or high idle, hot or cold. Very low-frequency drumming is very rpm dependent	• Engine vibration excites the body resonances inducing interior noise	• CARRY OUT the **POWERTRAIN/DRIVETRAIN MOUNT NEUTRALIZING** procedure.
• Engine drumming noise - accompanied by vibration	• Powertrain mount (s)	• CARRY OUT the **POWERTRAIN/DRIVETRAIN MOUNT NEUTRALIZING** procedure.
• Rattle - occurs at idle or at light acceleration from a stop	• Powertrain mount (s)	• CHECK the powertrain mounts for damage. INSTALL new mounts as necessary. For engine, Refer to the appropriate Engine article for the procedure. For automatic transmission, Refer to the appropriate Automatic Transmission article for the procedure. For manual transmission, REFER to

		MANUAL TRANSAXLE/TRANSMISSION .
• Whine/moan type noise - pitch increases or changes with vehicle speed	• Powertrain mount (s)	• CHECK the powertrain mounts for damage. INSTALL new mounts as necessary. For engine, Refer to the appropriate Engine article for the procedure. For automatic transmission, Refer to the appropriate Automatic Transmission article for the procedure. For manual transmission, REFER to **MANUAL TRANSAXLE/TRANSMISSION** .
• Clunk - occurs when shifting from PARK or between REVERSE and DRIVE	• Powertrain mount (s) • Idle speed is too high	• CHECK the powertrain/drivetrain mounts for damage. INSTALL new mounts as necessary. For engine, Refer to the appropriate Engine article for the procedure. For automatic transmission, Refer to the appropriate Automatic Transmission article for the procedure. For manual transmission, REFER to **MANUAL TRANSAXLE/TRANSMISSION** . • CHECK for the correct idle speed.
• Accessory drive bearing hoot - occurs at idle or high idle in cold temperatures of approximately +4°C (+40°F) or colder at the first start of the day	• Accessory drive idler or tensioner pulley bearing is experiencing stick/slip between ball bearings and the bearing race	• CARRY OUT the engine cold soak procedure. REFER to **NOISE, VIBRATION AND HARSHNESS** . • PLACE the EngineEAR probe directly on the idler/tensioner center post or bolt to verify which bearing is making the noise. INSTALL new parts as necessary. Refer to the appropriate Engine article for the procedure.
• Accessory drive belt noise, squeal or chirping	• Defective/worn or incorrect accessory drive belt • Misaligned pulley (s) • Pulley runout • Damaged or worn accessory drive component or idler • Fluid contamination of the accessory drive belt or pulleys • Damaged or worn accessory drive belt tensioner	• CARRY OUT the Engine Accessory Test. REFER to **NOISE, VIBRATION AND HARSHNESS** . INSPECT components and INSTALL new parts as necessary. REFER to **ACCESSORY DRIVE** .

	• Damaged pulley grooves	
• Clunking noise	• Coolant pump has excessive end play or imbalance	• CHECK the coolant pump for excessive end play. INSPECT the coolant pump for imbalance with the drive belt off. INSTALL a new coolant pump as necessary. REFER to **ENGINE COOLING** .
• Whine or moaning noise	• Air intake system	• CHECK the air cleaner and ducts for correct fit. INSPECT the air intake system for leaks or damage. REPAIR as necessary.
• Whistling noise - normally accompanied with poor idle condition	• Air intake system	• CHECK the air intake ducts, air cleaner, throttle body and vacuum hoses for leaks and correct fit. REPAIR or ADJUST as necessary.
• Hissing noise - occurs during idle or high idle that is apparent with the hood open	• Vacuum leak noise	• USE the Ultrasonic Leak Detector/EngineEAR to locate the source. SCAN the air intake system from the inlet to each cylinder intake port. DISCARD the leaking parts and INSTALL a new component.
	• Vehicles with a plastic intake manifold	• Acceptable condition. Some plastic manifolds exhibit this noise, which is the effect of the plastic manifold.
• Grinding noise - occurs during engine cranking	• Incorrect starter motor mounting	• INSPECT the starter motor for correct mounting. REPAIR as necessary. Refer to the appropriate Engine article for the procedure.
	• Starter motor	• CHECK the starter motor. INSTALL a new starter motor as necessary. Refer to the appropriate Engine article for the procedure.
	• Incorrect starter motor drive engagement	• INSPECT the starter motor drive for wear or damage. INSTALL a new starter motor as necessary. Refer to the appropriate Engine article for the procedure.
		• INSPECT the flywheel/flexplate for wear or damage. INSTALL a new flywheel/flexplate as necessary. Refer to the appropriate Engine article for the procedure.
• Engine noise, front of engine - knocking noise from lower front of engine	• Damaged or separated crankshaft pulley/damper	• CHECK for obvious signs of damage or wobble during operation. INSTALL new as necessary. Refer to the appropriate Engine article for the procedure.

• Engine noise, front of engine - ticking, tapping or rattling noise from the front of the engine	• Timing drive components	• REMOVE the accessory drive belt. Refer to the appropriate Engine article for the procedure. • USE the EngineEAR to isolate the noise to the engine front cover. • REMOVE the engine front cover and INSPECT the timing drive components. INSTALL new parts as necessary. Refer to the appropriate Engine article for the procedure.
• Engine noise, upper end - ticking noise near the fuel rail and intake manifold	• Fuel rail clip • Fuel injector	• CHECK for loose or damaged fuel rail clip (s). REPAIR as antecessor. • USE the EngineEAR to isolate the noisy injector(s). INSTALL new injector(s) as necessary. Refer to the appropriate Engine article for the procedure.
• Engine noise, upper end - ticking, knocking or rattle noise that occurs during idle or high idle during the first cold start of the day and may disappear as the engine warms	• Valve train noise (bled down lifter/lash adjuster)	• CARRY OUT the Valve Train Analysis Component Test. INSTALL new parts as necessary. Refer to the appropriate Engine article for the procedure.
• Engine noise, upper end - occurs mostly with a warm engine at light/medium acceleration	• Worn or damaged spark plugs • Carbon accumulation in combustion chamber	• REMOVE the spark plugs. INSPECT and INSTALL new as necessary. Refer to the appropriate Engine article for the procedure. • Bore scope the cylinder. ELIMINATE carbon buildup.
• Engine noise, upper end - rattling noise from the valve train. Worse when	• Low oil level	• CHECK the oil level. FILL as necessary.

the engine is cold	• Thin or diluted oil	• INSPECT the oil for contamination. If the oil is contaminated, CHECK for the source. REPAIR as necessary. CHANGE the oil and filter.
	• Low oil pressure	• CARRY OUT an oil pressure test. If not within specifications, REMOVE the engine oil pan. Refer to the appropriate Engine article for the procedure. INSPECT for a blocked oil pickup tube.
	• Worn valve train components	• CARRY OUT the Valve Train Analysis Component Test. INSTALL new parts as necessary. Refer to the appropriate Engine article for the procedure.
	• Worn valve guides	• CARRY OUT the **VALVE GUIDE INNER DIAMETER** procedure.
	• Excessive runout of the valve seats on the valve face	• CARRY OUT the **VALVE SEAT INSPECTION** procedure.
• Engine noise, upper end - pinging noise	• Gasoline octane too low	• VERIFY with customer the type of gasoline used. CORRECT as necessary.
	• Knock sensor operation	• CHECK the knock sensor. INSTALL a new knock sensor as necessary. Refer to the appropriate Engine article for the procedure.
	• Incorrect spark timing	• REFER to the **INTRODUCTION - GASOLINE MODELS** .
	• High operating temperature	• INSPECT the cooling system for leaks. CHECK the coolant level. REFILL as necessary. CHECK the coolant for the correct mix ratio. DRAIN and REFILL as needed. VERIFY the engine operating temperature is within specifications. REPAIR as necessary.
	• Spark plug	• CHECK the spark plugs. REPAIR or INSTALL new spark plugs as necessary.
	• Catalytic converter	• Acceptable noise.
• Engine noise, lower end - ticking or knocking noise near the oil filter adapter	• Oil pump	• USE the EngineEAR to verify the oil pump as the source of the noise at low rpm. REPAIR as necessary. Refer to the appropriate Engine article for the procedure.
• Engine noise, lower end - light		

knocking noise, also described as piston slap. Noise is most noticeable when the engine is cold with light to medium acceleration. The noise disappears as the engine warms	• Excessive clearance between the piston and the cylinder wall	• CARRY OUT the **PISTON TO CYLINDER BORE CLEARANCE** procedure.
• Engine noise, lower end - light double knock or sharp rap sound. Occurs mostly with a warm engine at idle or low speeds in drive. Increases in relation to engine load. Associated with a poor lubrication history	• Excessive clearance between the piston and the piston pin	• CARRY OUT the **PISTON PIN BORE DIAMETER** procedure.
	• Excessive clearance between the piston and the connecting rod	• CARRY OUT the **Connecting Rod-to-Piston Clearance** procedure.
• Engine noise, lower end - light knocking noise. The noise is most noticeable when the engine is warm. The noise tends to decrease when the vehicle is coasting or in NEUTRAL	• Excessive clearance between the connecting rod bearings and the crankshaft	• CARRY OUT the **Connecting Rod Bearing Journal-to-Bearing Clearance** procedure.
• Engine noise, lower end - deep knocking noise. The noise is most noticeable when the engine is warm, at lower rpm and under a light load and then at float	• Worn or damaged crankshaft main bearings	• CARRY OUT the **Crankshaft Main Bearing Journal-to-Bearing Clearance** procedure.

• Engine noise, rear of engine - knocking noise at rear of engine	• Damaged flywheel/flexplate	• CARRY OUT the **FLYWHEEL INSPECTION** or the **FLEXPLATE INSPECTION** procedure.
• Engine vibration - vibration felt at all times	• Excessive crankshaft pulley runout	• CARRY OUT the Engine Accessory Test. INSTALL a new crankshaft pulley as necessary. Refer to the appropriate Engine article for the procedure.
	• Damaged or worn accessory component	• CARRY OUT the Engine Accessory Test. REPAIR or INSTALL a new component as necessary.
• Engine vibration - at idle, a low-frequency vibration (5-20 Hz) or mild shake that is felt through the seat/floorpan	• Cylinder misfire	• Using the scan tool, CARRY OUT the cylinder power balance and the relative compression test. REPAIR as necessary. Refer to the appropriate Engine article for the procedure.
	• Engine or torque converter out of balance	• VERIFY the torque converter to crankshaft pilot clearance is correct. REPAIR as necessary. RE-INDEX the torque converter on the flex plate by 120 degrees for a 3-bolt converter or 180 degrees for a 4-bolt converter. Refer to the appropriate Automatic Transmission article for the procedure.
• Engine vibration - is felt with increases and decreases in engine rpm	• Powertrain mount (s)	• CHECK the powertrain mounts for damage. INSTALL new mounts as necessary. For engine, Refer to the appropriate Engine article for the procedure. For automatic transmission, Refer to the appropriate Automatic Transmission article for the procedure. For manual transmission, Refer to the appropriate Manual Transmission article for the procedure.
	• Engine or transmission grounded to chassis	• INSPECT the powertrain/drivetrain for correct clearances. REPAIR as necessary.
• Engine vibration - increases intensity as the engine rpm is increased	• Engine out-of-balance	• CARRY OUT the Neutral Engine Run-Up (NERU) Test. REFER to **NOISE, VIBRATION AND HARSHNESS** . ROTATE the torque converter, 120 degrees for 3-bolt or 180 degrees for 4-bolt. INSPECT the torque converter pilot outer diameter to crankshaft pilot inner diameter. REPAIR as necessary. Refer to the appropriate Automatic Transmission article

		for the procedure.
• Engine vibration - mostly at coast/neutral coast. Condition improves with vehicle acceleration	• Combustion instability	• CHECK the ignition system. INSTALL new components as necessary. Refer to the appropriate Engine article for the procedure.
• Engine vibration or shudder - occurs with light to medium acceleration above 56 km/h (35 mph)	• Worn or damaged spark plugs	• INSPECT the spark plugs for cracks, high resistance or broken insulators. INSTALL a new spark plug(s) as necessary. Refer to the appropriate Engine article for the procedure.
	• Plugged fuel injector	• REPAIR or INSTALL a new injector as necessary. Refer to the appropriate Engine article for the procedure.
	• Contaminated fuel	• INSPECT the fuel for contamination. DRAIN the fuel system and refill.

Component Tests

The following component tests are used to diagnose engine concerns.

Engine Oil Leaks

NOTE: If an overnight drive is done, the fan air or road air blast can cause erroneous readings.

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 12 Volt Master UV Diagnostic Inspection Kit to carry out the following procedure for oil leak diagnosis.

1. Add 29.6 ml (1 oz) of fluorescent additive to a minimum of 0.47L (1/2 qt) and a maximum of 0.95L (1 qt) engine oil and fill through the engine oil fill. If the oil is not premixed, the fluorescent additive will not have enough time to reach the crankcase, oil galleries and seal surfaces during this particular 15 minute test. The additive must be mixed with oil and added through the oil fill. Check the level on the oil level indicator to determine what amount of oil to premix. If it is in the middle of the crosshatch area or below the full mark, use 0.95L (1 qt). If it is at the full mark, use 0.47L (1/2 qt).
2. Run the engine for 15 minutes. Stop the engine and inspect all seal and gasket areas for leaks using the 12 Volt Master UV Diagnostic Inspection 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.

3. At the end of the test, make sure the oil level is within the upper and lower oil indicator marks. Remove oil as necessary if it registers above the full mark.

Leakage Points - Underhood

Examine the following areas for oil leakage:

- Valve cover gaskets
- Intake manifold gaskets
- Cylinder head gaskets
- Oil filter
- Oil filter adapter
- Engine front cover
- Oil filter adapter and filter body
- Oil level indicator tube connection
- Oil pressure sensor

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 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 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% 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)	1,131 kPa (164 psi)	848 kPa (123 psi)	1,338 kPa (194 psi)	1,000 kPa (146 psi)	1,544 kPa (224 psi)	1,158 kPa (168 psi)
938 kPa (136 psi)	703 kPa (102 psi)	1,145 kPa (166 psi)	855 kPa (124 psi)	1,351 kPa (196 psi)	1,014 kPa (147 psi)	1,558 kPa (226 psi)	1,165 kPa (169 psi)
952 kPa (138 psi)	717 kPa (104 psi)	1,158 kPa (168 psi)	869 kPa (126 psi)	1,365 kPa (198 psi)	1,020 kPa (148 psi)	1,572 kPa (228 psi)	1,179 kPa (171 psi)
965 kPa (140 psi)	724 kPa (106 psi)	1,172 kPa (170 psi)	876 kPa (127 psi)	1,379 kPa (200 psi)	1,034 kPa (150 psi)	1,586 kPa (230 psi)	1,186 kPa (172 psi)
979 kPa (142 psi)	738 kPa (107 psi)	1,186 kPa (172 psi)	889 kPa (129 psi)	1,303 kPa (202 psi)	1,041 kPa (151 psi)	1,600 kPa (232 psi)	1,200 kPa (174 psi)
933 kPa (144 psi)	745 kPa (109 psi)	1,200 kPa (174 psi)	903 kPa (131 psi)	1,407 kPa (204 psi)	1,055 kPa (153 psi)	1,055 kPa (153 psi)	1,207 kPa (175 psi)
1,007 kPa (146 psi)	758 kPa (110 psi)	1,214 kPa (176 psi)	910 kPa (132 psi)	1,420 kPa (206 psi)	1,062 kPa (154 psi)	1,627 kPa (154 psi)	1,220 kPa (177 psi)
1,020 kPa (148 psi)	765 kPa (111 psi)	1,227 kPa (178 psi)	917 kPa (133 psi)	1,434 kPa (208 psi)	1,075 kPa (156 psi)	1,641 kPa (238 psi)	1,227 kPa (178 psi)
1,034 kPa (150 psi)	779 kPa (113 psi)	1,241 kPa (180 psi)	931 kPa (135 psi)	1,448 kPa (210 psi)	1,083 kPa (157 psi)	1,655 kPa (240 psi)	1,241 kPa (180 psi)
1,048 kPa (152 psi)	786 kPa (114 psi)	1,255 kPa (182 psi)	936 kPa (136 psi)	1,462 kPa (212 psi)	1,089 kPa (158 psi)	1,669 kPa (242 psi)	1,248 kPa (181 psi)
1,062 kPa (154 psi)	793 kPa (115 psi)	1,269 kPa (184 psi)	952 kPa (138 psi)	1,476 kPa (214 psi)	1,103 kPa (160 psi)	1,682 kPa (244 psi)	1,262 kPa (183 psi)
1,076 kPa (156 psi)	807 kPa (117 psi)	1,282 kPa (186 psi)	965 kPa (140 psi)	1,489 kPa (216 psi)	1,117 kPa (162 psi)	1,696 kPa (246 psi)	1,269 kPa (184 psi)
1,089 kPa (158 psi)	814 kPa (118 psi)	1,296 kPa (188 psi)	972 kPa (141 psi)	1,503 kPa (218 psi)	1,124 kPa (163 psi)	1,710 kPa (248 psi)	1,202 kPa (186 psi)
1,103 kPa (160 psi)	827 kPa (120 psi)	1,310 kPa (190 psi)	979 kPa (142 psi)	1,517 kPa (220 psi)	1,138 kPa (165 psi)	1,724 kPa (250 psi)	1,289 kPa (187 psi)

1,110 kPa (161 psi)	834 kPa (121 psi)	1,324 kPa (192 psi)	993 kPa (144 psi)	1,631 kPa (222 psi)	1,145 kPa (166 psi)	-	-

If one or more cylinders read 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 within 75% of the highest reading.

Cylinder Leakage Detection

When a cylinder produces a low reading during the compression test, use of a cylinder leakage tester will be helpful in pinpointing the exact cause.

The leakage tester 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, the leakage tester gauge will read the percentage of leakage. Leakage exceeding 20% 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 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.

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's Literature. 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 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**.
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 passage 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.
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 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 1L (1 qt) 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 1L (1 qt) 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 oil level indicator 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 mi), 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 liter (quart) has been used, record the vehicle mileage. The mileage driven between the 2 readings should not be less than 2,400 km (1,500 mi). 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 - Test Results** for pressure range limits.
2. Compression should be consistent across all cylinders. Refer to the **COMPRESSION TEST - Test Results** . If compression tested within the specifications found, the excessive oil consumption may be due to wear on the valve guides, valves or valve seals.
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 indicate excessive oil use. A typical engine with normal oil

consumption will exhibit a light tan to brown appearance. See Spark Plug Inspection 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 the engine is complete and verification that all pre-check items were eliminated in the original diagnosis, repeat the Oil Consumption Test as described above and verify consumption results.

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 ft) 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.

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.

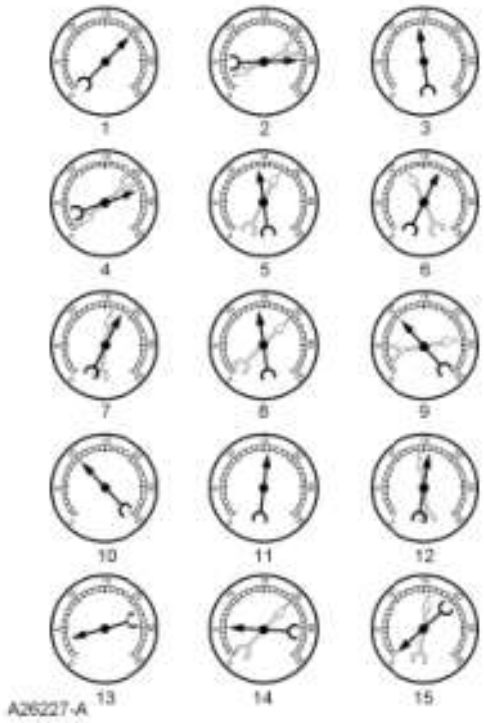


Fig. 1: Intake Manifold Vacuum Test - Interpreting Vacuum Gauge Readings
Courtesy of FORD MOTOR CO.

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 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.
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.

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 appropriate Engine article .
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 - Camshafts

- Check for broken or damaged parts.
- Check for loose mounting bolts on camshaft caps.

Valve Train Analysis - Camshaft Roller Followers and Hydraulic Lash Adjusters, 4.0L SOHC Engines

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

Valve Train Analysis - Valve Springs

- Check for broken or damaged parts.

Valve Train Analysis - 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 - Valves and Cylinder Head

- Check for plugged oil drain back holes.
- Check for worn or damaged valve tips.
- Check for missing or damaged valve stem seals.
- Check collapsed valve tappet gap.
- Check installed valve spring height.
- Check for missing or worn valve spring seats.
- Check for plugged oil drain back holes.

Valve Train Analysis - Camshaft Lobe Lift

Valve Train Analysis - Camshaft Lobe Lift, 2.3L

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

1. Remove the valve cover. Refer to **ENGINE - 2.3L** .
2. Remove the spark plugs. Refer to **ENGINE IGNITION - 2.3L** .
3. Install the Dial Indicator Gauge with Holding Fixture so the rounded tip of indicator is on top of the camshaft lobe.
4. Rotate the crankshaft using a breaker bar and a socket attached to the crankshaft pulley bolt. Rotate the crankshaft until the base circle of the camshaft lobe is reached.

Typical Engine With Valve Tappets

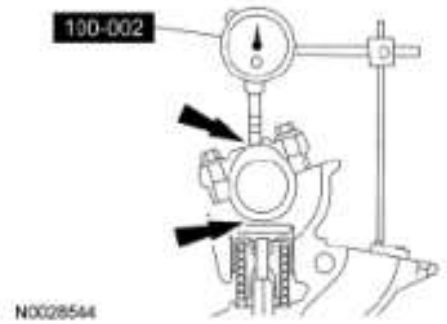


Fig. 2: Lifting Of Crankshaft Lobe - Typical Engine With Valve Tappets
Courtesy of FORD MOTOR CO.

5. Zero the Dial Indicator. Continue to rotate the crankshaft until the high-lift point of the camshaft lobe

is in the fully-raised position (highest indicated reading).

6. To check the accuracy of the original indicator reading, continue to rotate the crankshaft until he vase circle is reached. The indicator reading should be zero. If a zero reading is not obtained, repeat the measurement.
7. If the lift on any camshaft lobe is below specified service limits, install a new camshaft and valve tappets. Refer to **ENGINE - 2.3L** .
8. Install the spark plugs. Refer to **ENGINE IGNITION - 2.3L** .
9. Install the valve cover. Refer to **ENGINE IGNITION - 2.3L** .

Valve Train Analysis - Camshaft Lobe Lift, 4.0L SOHC Engines

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

1. Remove the valve covers. Refer to **ENGINE - 4.0L SOHC** .
2. Remove the spark plugs. Refer to **ENGINE IGNITION - 4.0L SOHC** .
3. Install the Dial Indicator Gauge with Holding Fixture so the rounded tip of indicator is on top of the camshaft lobe.
4. Rotate the crankshaft using a breaker bar and socket attached to the crankshaft pulley bolt. Rotate the crankshaft until the base circle of the camshaft lobe is reached.

Typical Engine With Camshaft Roller Followers

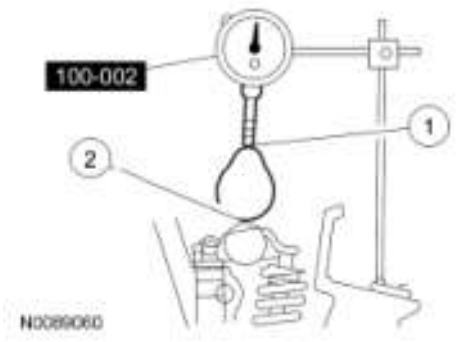


Fig. 3: Lifting Of Crankshaft Lobe - Typical Engine With Camshaft Roller Followers
Courtesy of FORD MOTOR CO.

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 the measurement.
7. If the lift on any lobe is below specified service limits, install a new camshaft, and new camshaft roller followers. Refer to **ENGINE - 4.0L SOHC** .
8. Install the spark plugs. Refer to **ENGINE IGNITION - 4.0L SOHC** .
9. Install the valve covers. Refer to **ENGINE - 4.0L SOHC** .

Valve Train Analysis - Hydraulic Lash Adjusters

Hydraulic lash adjuster noise can be caused by any of the following:

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

Excessive collapsed hydraulic lash adjuster gap can be caused by loose rocker arm seat bolts/nuts, incorrect initial adjustment or wear of hydraulic lash adjuster face, or worn roller hydraulic lash adjuster, push rod, rocker arm, rocker arm seat or valve tip. With hydraulic lash adjuster 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 hydraulic lash adjuster can be sticking, caused by contaminants or varnish inside the hydraulic lash adjuster. The hydraulic lash adjuster 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 hydraulic lash adjuster with a leakdown time out of specification can cause hydraulic lash adjuster noise. If no other cause for noisy hydraulic lash adjuster can be found, the leakdown rate should be checked and new hydraulic lash adjusters installed if found to be out of specification.

Assembled hydraulic lash adjusters can be tested with a commercially available 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 hydraulic lash adjuster 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.

GENERAL PROCEDURES

SPROCKETS

1. Inspect the sprockets for cracks and worn or chipped teeth.

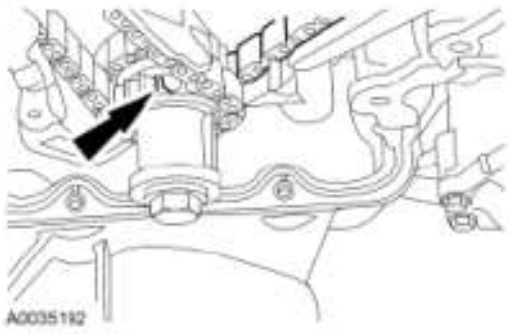


Fig. 4: Locating Sprockets For Cracks
Courtesy of FORD MOTOR CO.

CAMSHAFT BEARING JOURNAL DIAMETER

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. Measure each camshaft journal diameter in 2 directions.

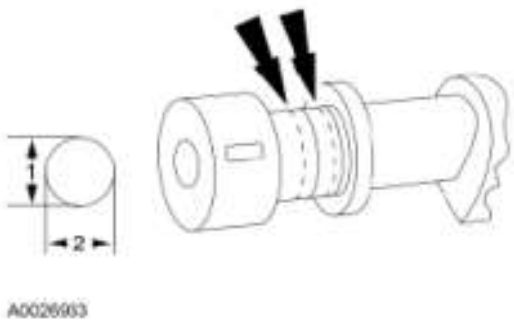


Fig. 5: Measuring Camshaft Journal
Courtesy of FORD MOTOR CO.

CAMSHAFT JOURNAL TO BEARING CLEARANCE - OHC ENGINES

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. **NOTE:** **The camshaft journals must meet specifications before checking camshaft journal clearance.**

   Measure each camshaft bearing in 2 directions.

   - Subtract the camshaft journal diameter from the camshaft bearing diameter.

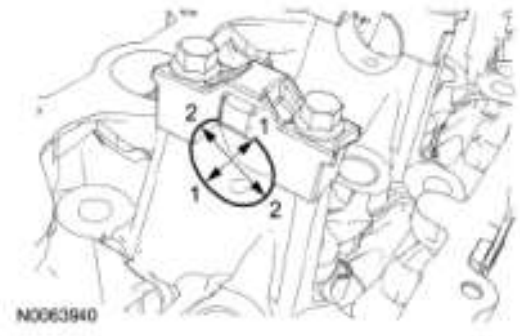
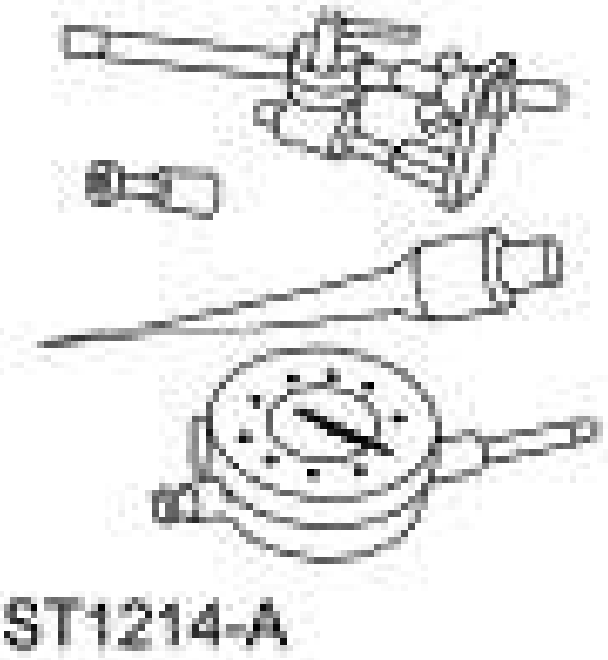


Fig. 6: Measuring Camshaft Bearing
Courtesy of FORD MOTOR CO.

CAMSHAFT END PLAY - OHC ENGINES

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Using the Dial Indicator Gauge with Holding Fixture, measure the camshaft end play.
2. Position the camshaft to the rear of the cylinder head.
3. Zero the Dial Indicator Gauge.
4. Move the camshaft to the front of the cylinder head. Note and record the camshaft end play.
   - If camshaft end play exceeds specifications, install a new camshaft and recheck end play.
   - If camshaft end play exceeds specification after camshaft installation, install a new cylinder head.

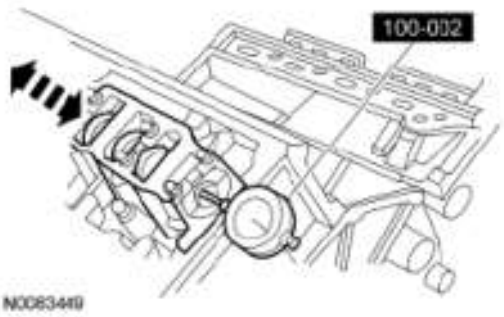


Fig. 7: Measuring Camshaft End Play
Courtesy of FORD MOTOR CO.

CAMSHAFT SURFACE INSPECTION

1. Inspect camshaft lobes for pitting or damage in the contact area. Minor pitting is acceptable outside

the contact area.

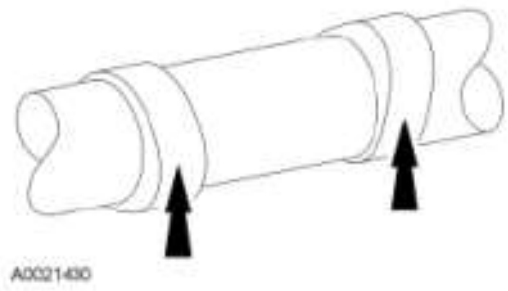
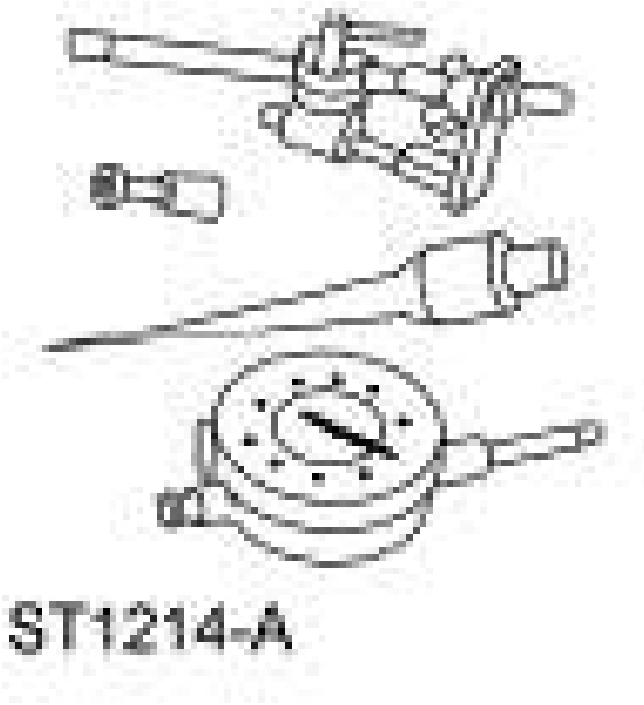


Fig. 8: Locating Camshaft Lobes
Courtesy of FORD MOTOR CO.

CAMSHAFT LOBE LIFT

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Use the Dial Indicator Gauge with Holding Fixture to measure camshaft intake/exhaust lobe lift.
    - Rotate the camshaft and subtract the lowest Dial Indicator Gauge reading from the highest Dial Indicator Gauge reading to figure the camshaft lobe lift.

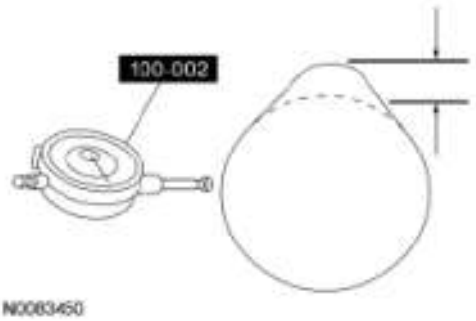


Fig. 9: Measuring Camshaft Intake/Exhaust Lobe Lift
Courtesy of FORD MOTOR CO.

CAMSHAFT RUNOUT

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: Camshaft journals must be within specifications before checking runout.

1. Using the Dial Indicator Gauge with Holding Fixture, measure the camshaft runout.
   - Rotate the camshaft and subtract the lowest Dial Indicator Gauge reading from the highest Dial Indicator Gauge reading.

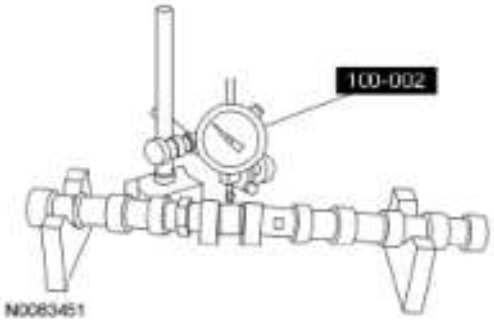


Fig. 10: Measuring Camshaft Runout
Courtesy of FORD MOTOR CO.

CRANKSHAFT MAIN BEARING JOURNAL DIAMETER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure each of the crankshaft main bearing journal diameters in at least 2 directions.

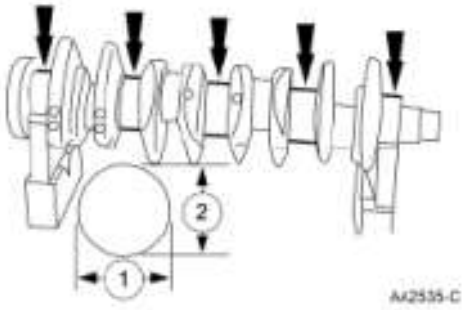


Fig. 11: Measuring Crankshaft Main Bearing Journal Diameters
Courtesy of FORD MOTOR CO.

CRANKSHAFT MAIN BEARING JOURNAL TAPER AND OUT-OF-ROUND

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure each of the crankshaft main bearing journal diameters in at least 2 directions at each end of the main bearing journal.

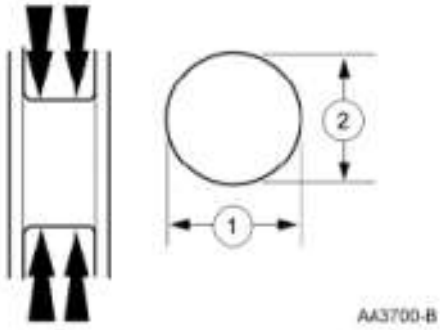


Fig. 12: Measuring Crankshaft Main Bearing Journal Diameters
Courtesy of FORD MOTOR CO.

CRANKSHAFT MAIN BEARING JOURNAL-TO-BEARING CLEARANCE

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: Crankshaft main bearing journals must be within specifications before checking journal clearance.

1. Remove the crankshaft main bearing caps and crankshaft main bearing.
2. Lay a piece of Plastigage across the face of each crankshaft main bearing surface.

Fig. 13: Laying Piece Of Plastigage Across Face Of Crankshaft Main Bearing Surface
Courtesy of FORD MOTOR CO.

3. **NOTE: Do not turn the crankshaft while carrying out this procedure.**

   Install and remove the crankshaft main bearing cap.

4. Verify the crankshaft journal clearance.

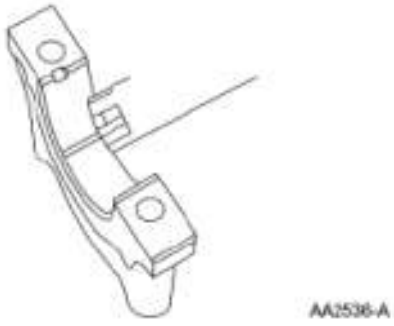
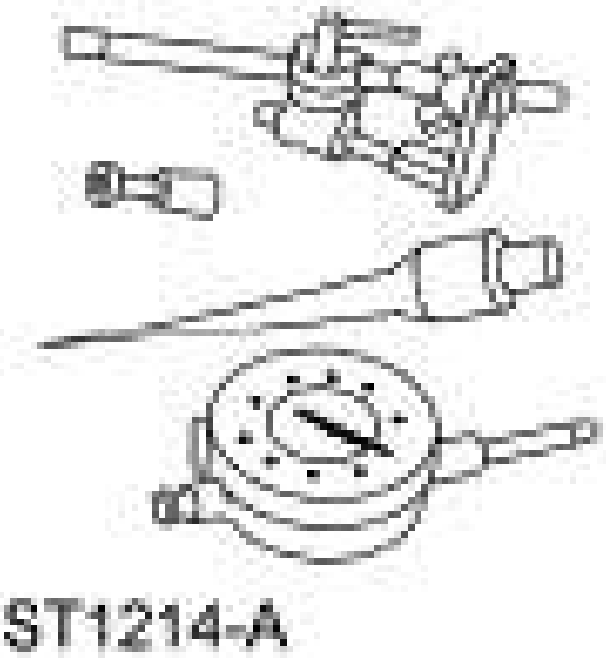


Fig. 14: Identifying Crankshaft Journal Clearance
Courtesy of FORD MOTOR CO.

CRANKSHAFT END PLAY

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Install the Dial Indicator Gauge with Holding Fixture.
2. Position the crankshaft to the rear of the cylinder block.
3. Zero the Dial Indicator Gauge.
4. Move the crankshaft to the front of the cylinder block. Note and record the crankshaft end play.

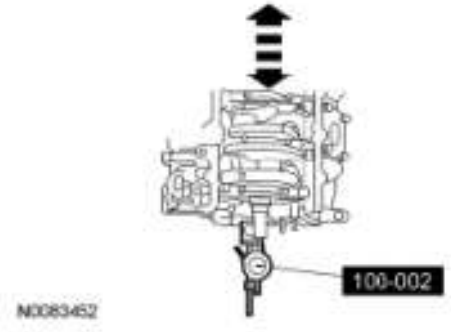


Fig. 15: Checking Crankshaft End Play
Courtesy of FORD MOTOR CO.

CONNECTING ROD BEARING JOURNAL TAPER AND OUT-OF-ROUND

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the crankshaft connecting rod journal diameters in 2 directions perpendicular to one another at each end of the connecting rod journal. The difference in the measurements from one end to the other is the taper. Verify measurement is within the wear limit.

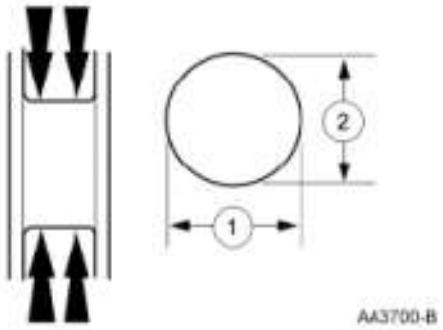


Fig. 16: Measuring Crankshaft Connecting Rod Journal Diameters
Courtesy of FORD MOTOR CO.

CYLINDER BORE TAPER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the cylinder bore at the top, middle and bottom of piston ring travel in 2 directions as indicated. Verify the cylinder bore is within the wear limit. The difference indicates the cylinder bore taper. Bore the cylinder to the next oversize limit.

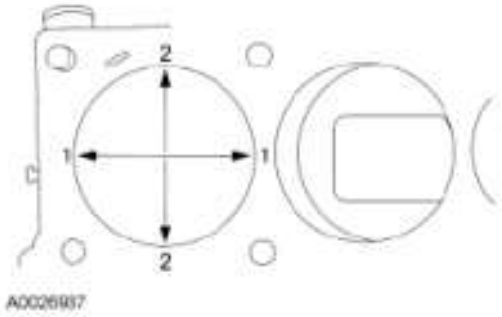


Fig. 17: Measuring Cylinder Bore Top, Middle And Bottom Of Piston Ring Travel
Courtesy of FORD MOTOR CO.

CYLINDER BORE OUT-OF-ROUND

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the cylinder bore in 2 directions. The difference is the out-of-round.

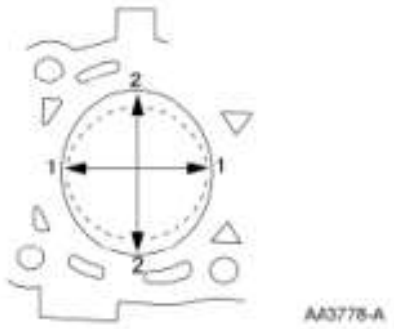


Fig. 18: Measuring Cylinder Bore Directions
Courtesy of FORD MOTOR CO.

PISTON INSPECTION

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Scraper, Piston Ring Groove 303-D033 (D81L-6002-D) or equivalent

NOTE: Do not use a caustic cleaning solution or a wire brush to clean the pistons or damage can occur.

1. Clean and inspect the (1) ring lands, (2) skirts, (3) pin bosses and the (4) tops of the pistons. If wear marks, scores or glazing is found on the piston skirt, check for a bent or twisted connecting rod.

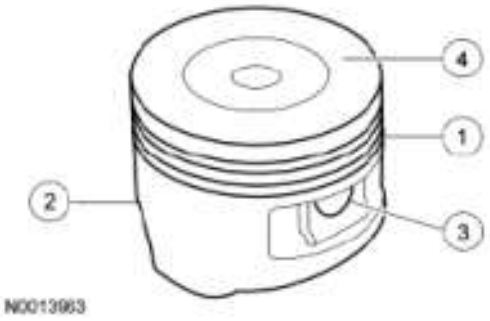


Fig. 19: Identifying Ring Lands, Skirts And Pin Bosses
Courtesy of FORD MOTOR CO.

2. Use the Piston Ring Groove Scraper to clean the piston ring grooves.
   - Make sure the oil ring holes are clean.

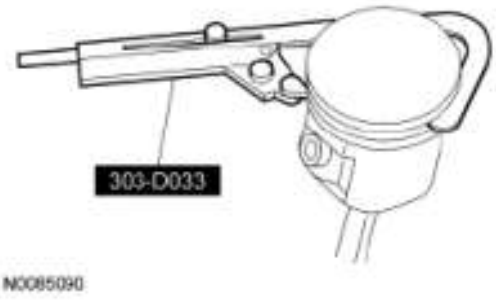


Fig. 20: Cleaning Piston Ring Grooves
Courtesy of FORD MOTOR CO.

PISTON PIN BORE DIAMETER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: Piston and piston pins are a matched set and should not be interchanged.

1. Measure the piston pin bore diameter in 2 directions on each side. Verify the diameter is within specification.

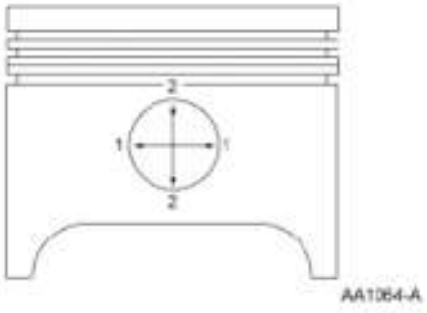


Fig. 21: Measuring Piston Pin Bore Diameter
Courtesy of FORD MOTOR CO.

PISTON DIAMETER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the piston diameter 90 degrees from the piston pin and 42 mm (1.65 in) down from the top of the piston at the point indicated.

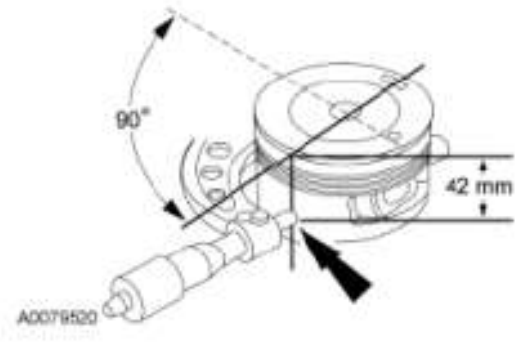


Fig. 22: Measuring Piston Diameter
Courtesy of FORD MOTOR CO.

PISTON TO CYLINDER BORE CLEARANCE

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

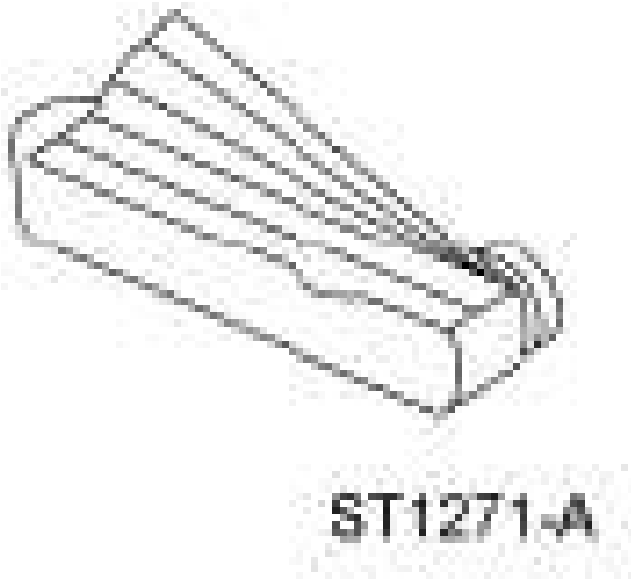
1. Subtract the piston diameter from the cylinder bore diameter to find the piston-to-cylinder bore clearance.

PISTON RING END GAP

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent



NOTE: Use care when fitting piston rings to avoid possible damage to the piston ring or the cylinder bore.

NOTE: Piston rings should not be transferred from one piston to another.

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: The cylinder bore must be within specification for taper and out-of-round.

1. Use a piston without rings to push a piston ring in a cylinder to the bottom of ring travel.

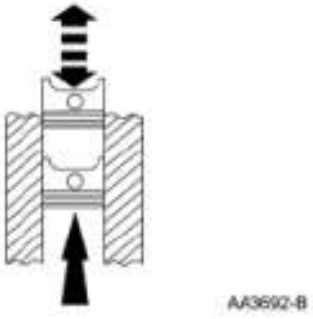


Fig. 23: Pushing Piston Ring In Cylinder To Bottom Of Ring Travel
Courtesy of FORD MOTOR CO.

2. Use the Feeler Gauge Set to measure the top piston ring end gap and the second piston ring end gap.

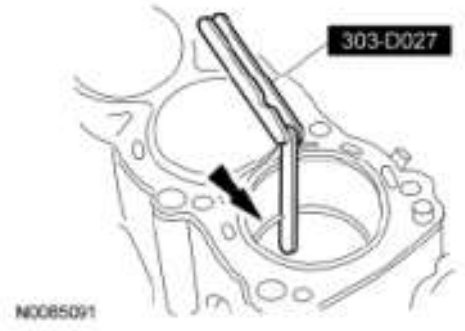
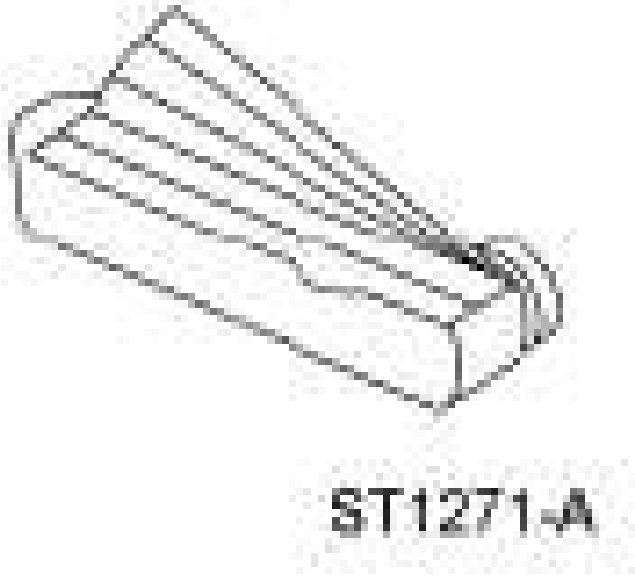


Fig. 24: Measuring Top Piston Ring End Gap
Courtesy of FORD MOTOR CO.

PISTON RING-TO-GROOVE CLEARANCE

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Inspect the piston for ring land damage or accelerated wear.

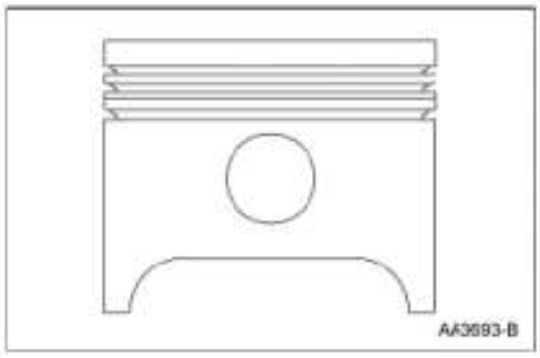


Fig. 25: Identifying Piston
Courtesy of FORD MOTOR CO.

2. Using the Feeler Gauge Set, measure the piston ring-to-groove clearance.

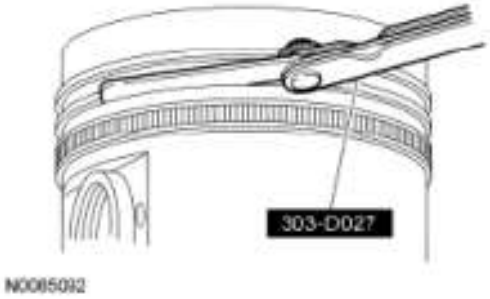


Fig. 26: Measuring Piston Ring-To-Groove Clearance
Courtesy of FORD MOTOR CO.

PISTON PIN DIAMETER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the piston pin diameter in 2 directions at the points shown in illustration. Verify the diameter is within specification.

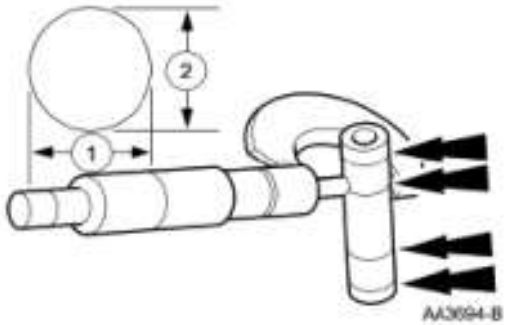


Fig. 27: Measuring Piston Pin Diameter
Courtesy of FORD MOTOR CO.

CONNECTING ROD CLEANING

NOTE: **Do not use a caustic cleaning solution or damage to connecting rods can occur.**

NOTE: **The connecting rod large end is a matched set. The connecting rod cap must be installed on the original connecting rod in the original position. Do not reverse the cap. Parts are not interchangeable.**

1. Mark and separate the parts and clean with solvent. Clean the oil passages.

Fig. 28: Identifying Connecting Rod Large End Installation Position
Courtesy of FORD MOTOR CO.

CONNECTING ROD LARGE END BORE

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. Tighten the bolts to specification, then measure the bore in 2 directions. The difference is the connecting rod bore out-of-round. Verify the out-of-round is within specification.

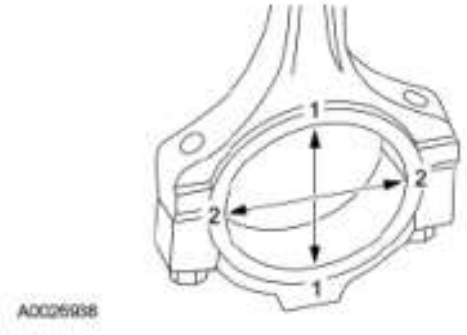


Fig. 29: Checking Connecting Rod Large End Bore
Courtesy of FORD MOTOR CO.

CONNECTING ROD BUSHING DIAMETER

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. Use a telescoping gauge to determine the ID of the connecting rod bushing, if equipped.

Fig. 30: Checking Connecting Rod Bushing Diameter
Courtesy of FORD MOTOR CO.

2. Measure the telescoping gauge with a micrometer. Verify the diameter is within specification.

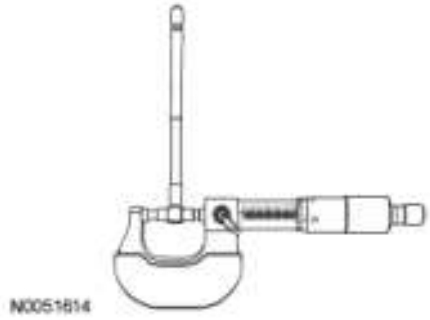
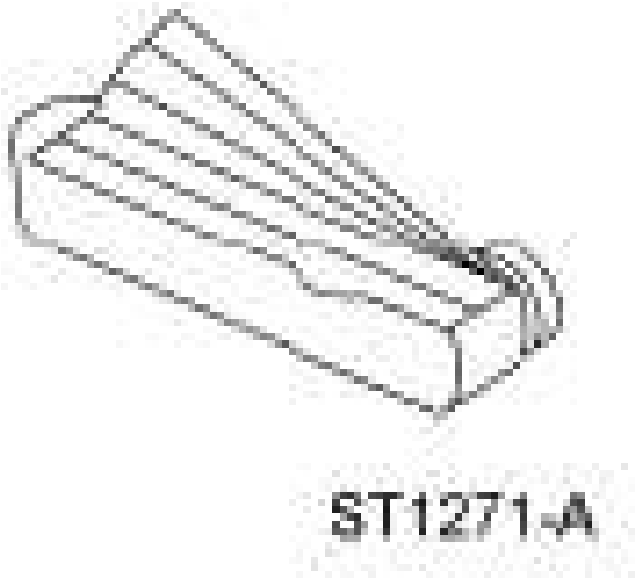


Fig. 31: Measuring Telescoping Gauge With Micrometer
Courtesy of FORD MOTOR CO.

CONNECTING ROD BEND

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Using the Feeler Gauge Set, measure the connecting rod bend on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the bend measurement is within specification.

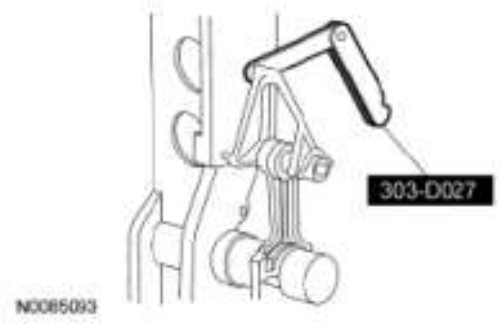
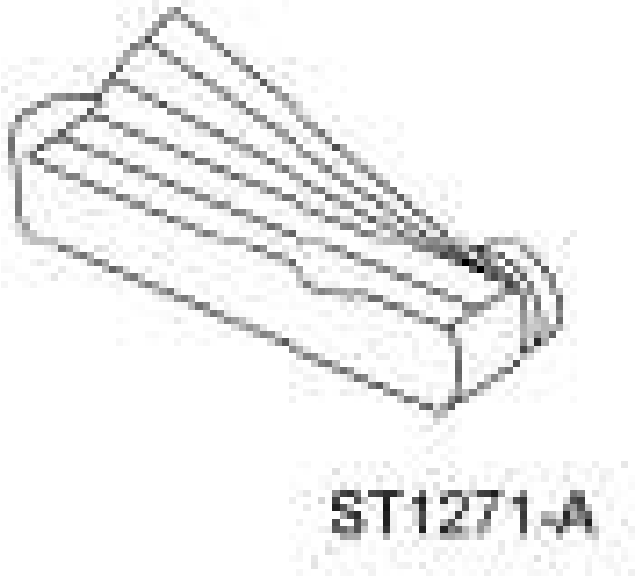


Fig. 32: Measuring Connecting Rod Bend On Suitable Alignment Fixture
Courtesy of FORD MOTOR CO.

CONNECTING ROD TWIST

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Using the Feeler Gauge Set, measure the connecting rod twist on a suitable alignment fixture. Follow the instructions of the fixture manufacturer. Verify the measurement is within specification.

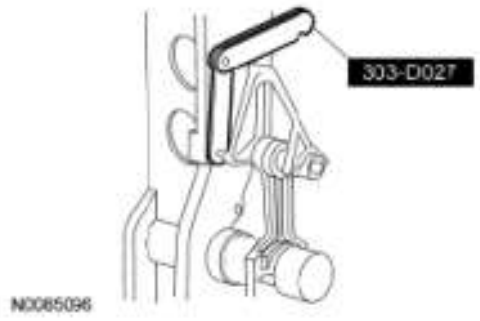


Fig. 33: Measuring Connecting Rod Twist On Suitable Alignment Fixture
Courtesy of FORD MOTOR CO.

CONNECTING ROD BEARING JOURNAL-TO-BEARING CLEARANCE

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: The crankshaft connecting rod journals must be within specifications to check the connecting rod bearing journal clearance.

1. Remove the connecting rod bearing cap.
2. Position a piece of Plastigage across the bearing surface.

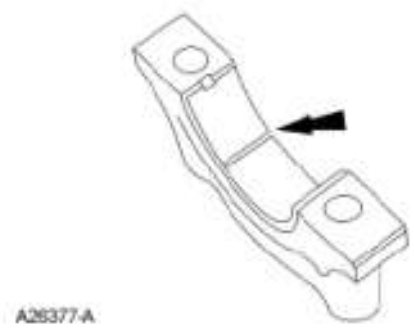


Fig. 34: Positioning Piece Of Plastigage Across Bearing Surface
Courtesy of FORD MOTOR CO.

3. **NOTE: Do not turn the crankshaft during this step.**

   Install and tighten to specifications, then remove the connecting rod bearing cap.

4. Measure the Plastigage to get the connecting rod bearing journal clearance. The Plastigage should be smooth and flat. A changing width indicates a tapered or damaged connecting rod or connecting rod bearing.

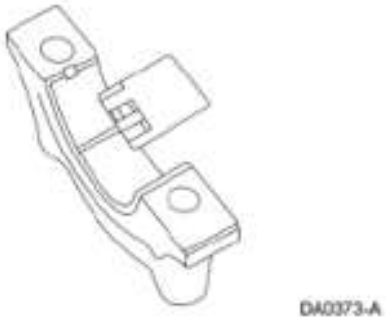
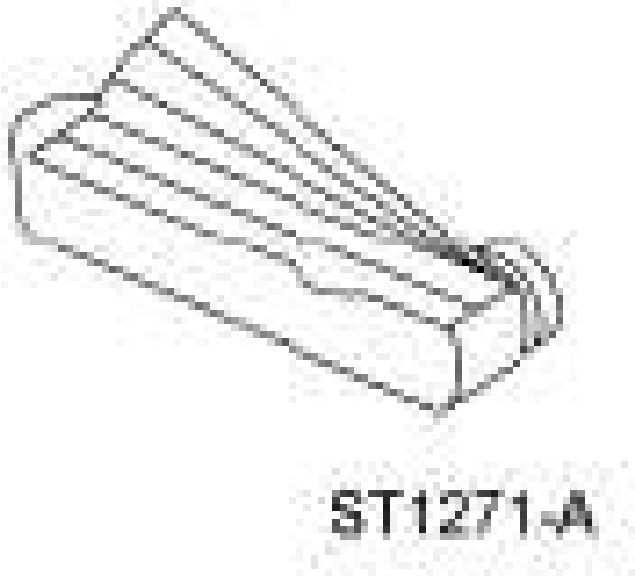


Fig. 35: Measuring Plastigage To Get Connecting Rod Bearing Journal Clearance
Courtesy of FORD MOTOR CO.

CONNECTING ROD TO CRANKSHAFT SIDE CLEARANCE

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Using the Feeler Gauge Set, measure the clearance between the connecting rod and the crankshaft. Verify the measurement is within specification.

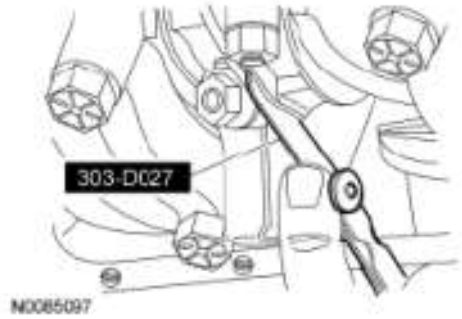
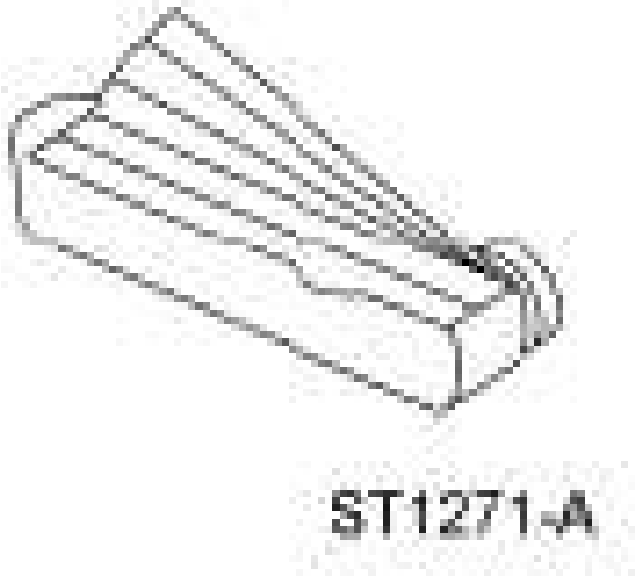


Fig. 36: Measuring Clearance Between Connecting Rod And Crankshaft
Courtesy of FORD MOTOR CO.

CONNECTING ROD-TO-PISTON CLEARANCE

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Using the Feeler Gauge Set, measure the clearance between the connecting rod and the piston. Verify the measurement is within specification.

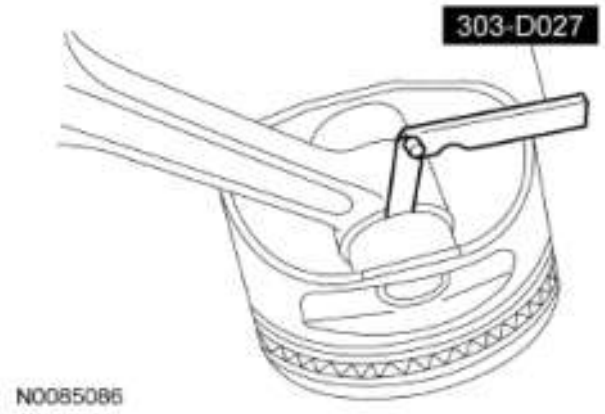


Fig. 37: Measuring Clearance Between Connecting Rod And Piston
Courtesy of FORD MOTOR CO.

ROLLER FOLLOWER INSPECTION

1. Inspect the roller follower for flat spots or scoring. If any damage is found, inspect the camshaft lobes and hydraulic lash adjuster for damage.

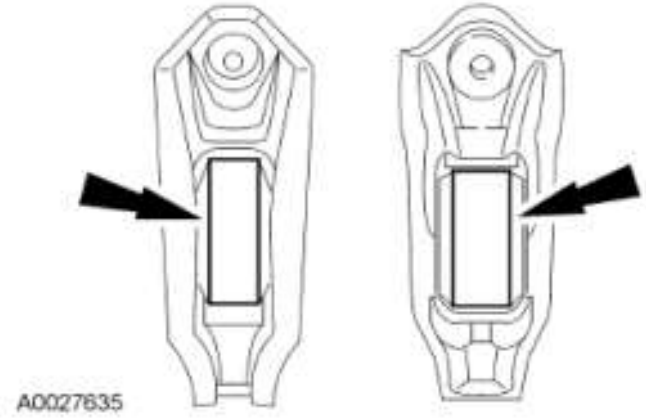


Fig. 38: Locating Roller Follower Damage Area
Courtesy of FORD MOTOR CO.

HYDRAULIC LASH ADJUSTER INSPECTION

1. Inspect the hydraulic lash adjuster and roller follower for damage. If any damage is found, inspect the camshaft lobes and valves for damage.

Fig. 39: Identifying Hydraulic Lash Adjuster Damage Area
Courtesy of FORD MOTOR CO.

VALVE TAPPET INSPECTION

OHC engines

1. Inspect the valve tappet for damage, especially in the indicated areas. If any damage is evident, inspect the camshaft lobes and valves for damage. Replace components as necessary.

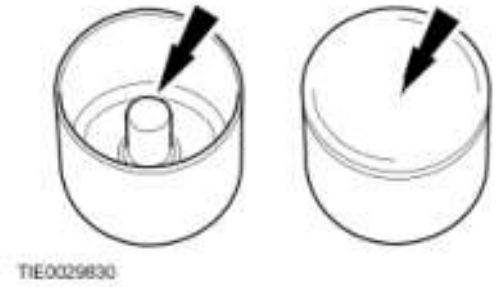


Fig. 40: Locating Valve Tappet
Courtesy of FORD MOTOR CO.

Push rod engines

Fig. 41: Locating Push Rod Engines
Courtesy of FORD MOTOR CO.

VALVE STEM DIAMETER

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. Measure the diameter of each intake and exhaust valve stem at the points shown in illustration. Verify the diameter is within specification.

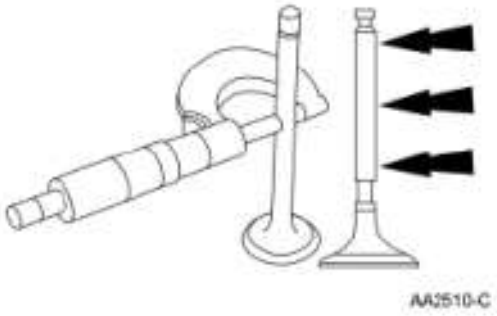
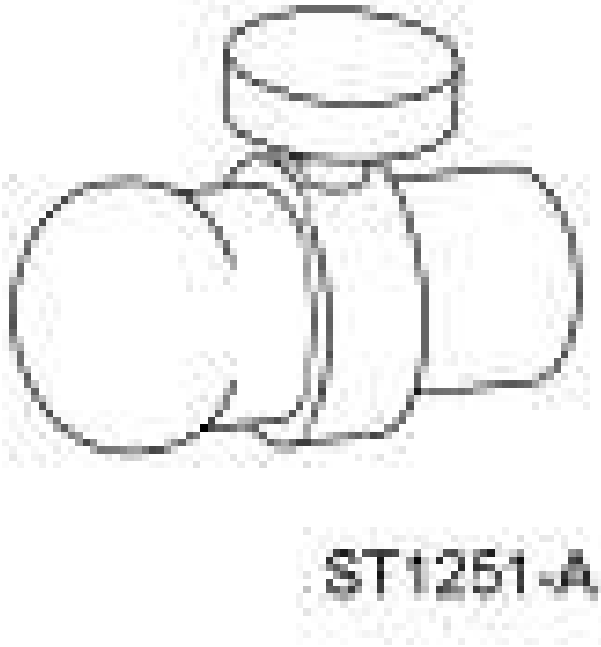


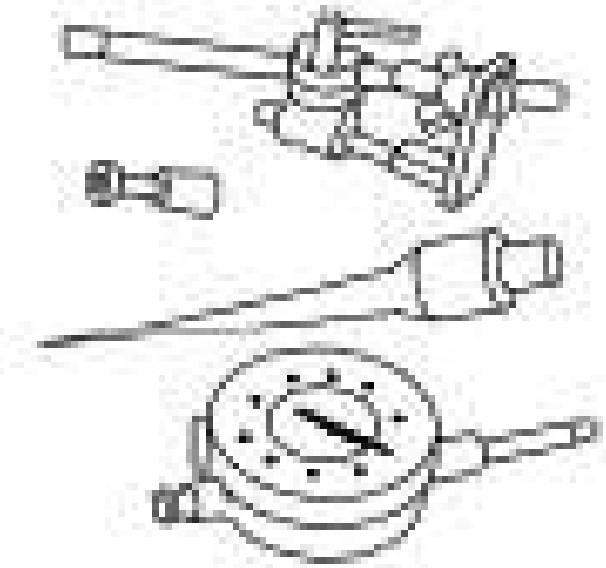
Fig. 42: Measuring Diameter Of Each Intake And Exhaust Valve Stem
Courtesy of FORD MOTOR CO.

VALVE STEM TO VALVE GUIDE CLEARANCE

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Clearance Gauge, Valve Guide 303-004 (TOOL-6505-E) or equivalent

	Dial Indicator Gauge with Holding Fixture 100-002 (TOOL-4201-C) or equivalent

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: The valve stem diameter must be within specifications before checking valve stem-to-valve guide clearance.

1. **NOTE: If necessary, use a magnetic base.**

   Install a Valve Guide Clearance Gauge on the valve stem and install a Dial Indicator Gauge with Holding Fixture. Lower the valve until the clearance gauge contacts the upper surface of the valve guide.

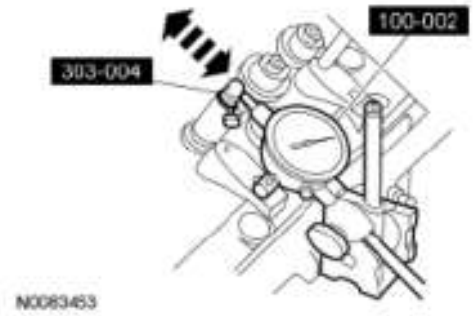


Fig. 43: Checking Valve Guide Clearance
Courtesy of FORD MOTOR CO.

2. Move the Valve Guide Clearance Gauge toward the Dial Indicator Gauge with Holding Fixture and zero the Dial Indicator Gauge. Move the Valve Guide Clearance Gauge away from the Dial Indicator Gauge with Holding Fixture and note the reading. The reading will be DOUBLE the valve stem-to-

valve guide clearance.

VALVE INSPECTION

1. Inspect the following valve areas:
    1. The end of the stem for grooves or scoring.
    2. The valve face and the edge for pits, grooves or scores.
    3. The valve head for signs of burning, erosion, warpage and cracking.
    4. The valve margin for wear.

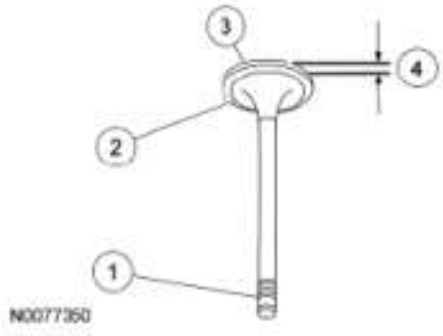


Fig. 44: Identifying Valve Margin For Wear
Courtesy of FORD MOTOR CO.

VALVE GUIDE INNER DIAMETER

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

NOTE: Valve guides tend to wear in an hourglass pattern. The ball gauge can be inserted into the combustion chamber side of the valve guide, if necessary.

1. Use a ball gauge to determine the inside diameter of the valve guides in 2 directions at the top, middle and bottom of the valve guide.

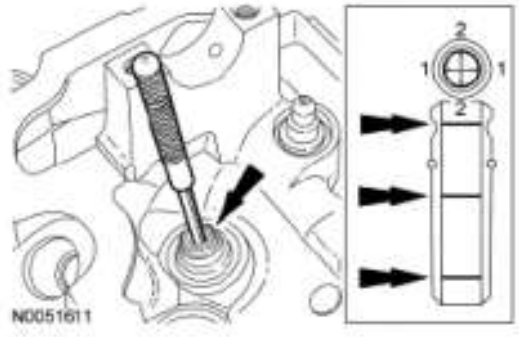


Fig. 45: Locating Valve Guides
Courtesy of FORD MOTOR CO.

2. Measure the ball gauge with a micrometer.

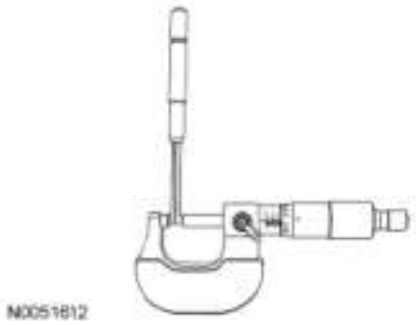


Fig. 46: Measuring Ball Gauge With Micrometer
Courtesy of FORD MOTOR CO.

3. If the valve guide is not within specifications, install a new cylinder head assembly.

VALVE SPRING INSTALLED LENGTH

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the installed length of each valve spring.

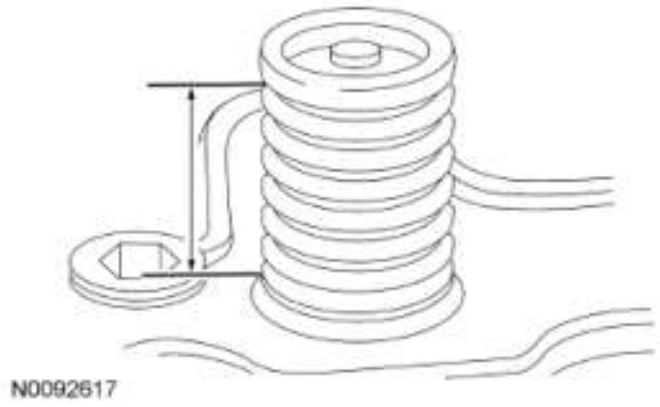


Fig. 47: Measuring Installed Length Of Each Valve Spring
Courtesy of FORD MOTOR CO.

VALVE SPRING FREE LENGTH

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the free length of each valve spring.

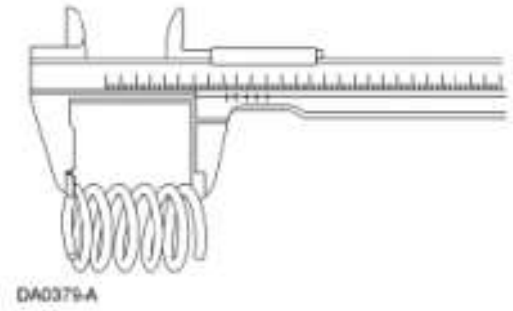


Fig. 48: Measuring Free Length Of Each Valve Spring
Courtesy of FORD MOTOR CO.

VALVE SPRING SQUARENESS

1. Measure the out-of-square on each valve spring.
    - Turn the valve spring and observe the space between the top of the valve spring and the square.

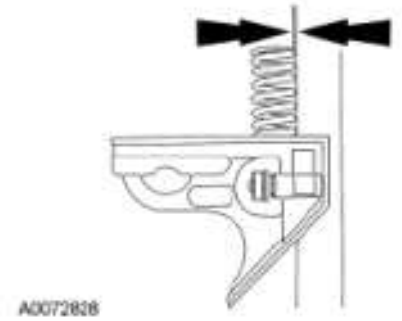


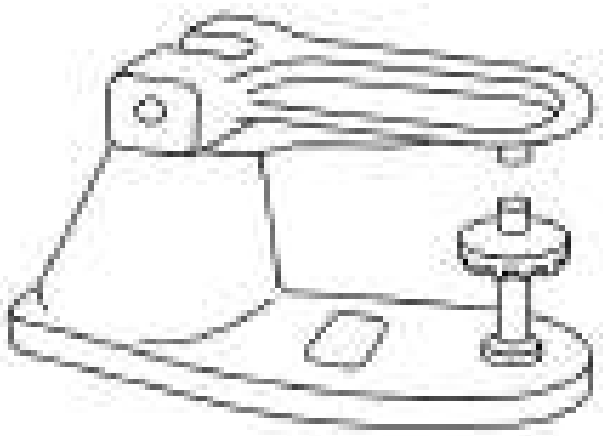
Fig. 49: Measuring Out-Of-Square On Each Valve Spring
Courtesy of FORD MOTOR CO.

VALVE SPRING STRENGTH

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Pressure Gauge, Valve/Clutch Spring 303-006 (TOOL-6513-DD) or equivalent



ST1278-A

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. Use the Valve/Clutch Spring Pressure Gauge to check the valve spring for correct strength at the specified valve spring length.

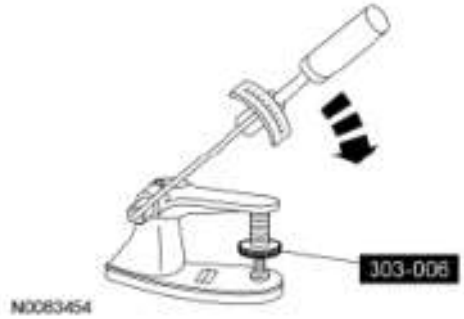


Fig. 50: Checking Valve Spring For Correct Strength Specified Valve Spring Length
Courtesy of FORD MOTOR CO.

VALVE SEAT INSPECTION

Valve and Seat Refacing Measurements

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

NOTE: **After grinding valves or valve seats, check valve clearance.**

1. Check the valve head and seat.
   - Check valve angles.

- Check margin width.
- Be sure margin width is within specification.

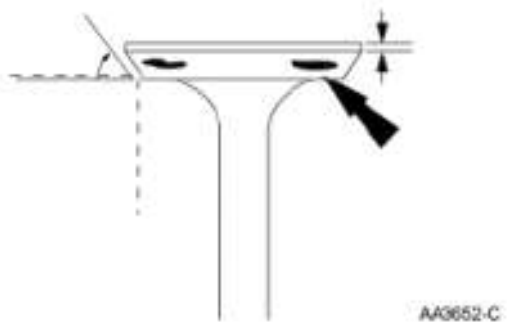


Fig. 51: Checking Valve Head And Seat
Courtesy of FORD MOTOR CO.

2. Inspect for abnormalities on the valve face and seat. Install a new cylinder head assembly if abnormalities are found.

VALVE SEAT WIDTH

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Measure the valve seat width. If necessary, grind the valve seat to specification.
   - Measure the intake valve seat width.
   - Measure the exhaust valve seat width.
   - Recheck the valve spring installed length after the seats have been ground, and shim the valve springs as necessary to achieve the correct installed spring length.

Fig. 52: Measuring Valve Seat Width
Courtesy of FORD MOTOR CO.

VALVE SEAT RUNOUT

NOTE: Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.

1. Use a valve seat runout gauge to check valve seat runout.

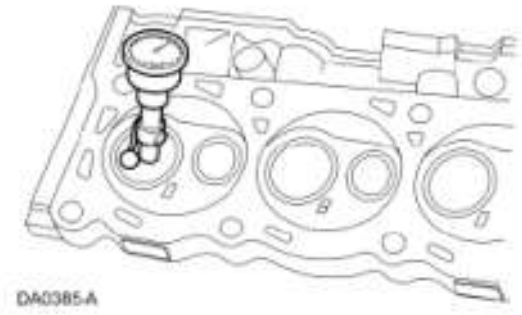


Fig. 53: Checking Valve Seat Runout
Courtesy of FORD MOTOR CO.

FLEXPLATE INSPECTION

1. Inspect the flexplate for:
    1. any cracks.
    2. worn ring gear teeth.
    3. chipped or cracked ring gear teeth.

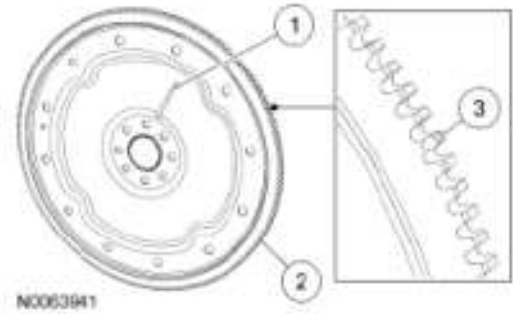


Fig. 54: Identifying Cracked Ring Gear Teeth
Courtesy of FORD MOTOR CO.

FLYWHEEL INSPECTION

1. **NOTE: The flywheel cannot be resurfaced, it must be replaced.**

    Inspect the flywheel for:

    1. any cracks.
    2. worn ring gear teeth.
    3. chipped or cracked ring gear teeth.
    4. scratches, nicks and discoloration.

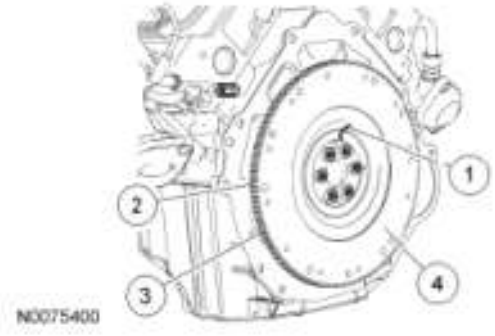
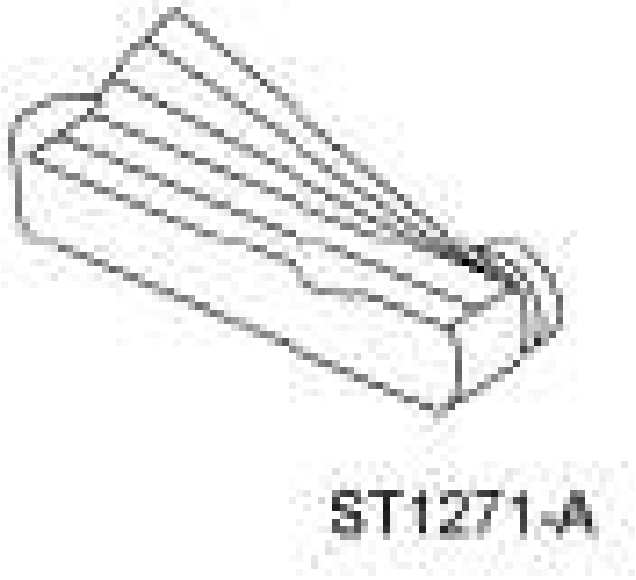


Fig. 55: Identifying Flywheel Cracks Area
Courtesy of FORD MOTOR CO.

CYLINDER HEAD DISTORTION

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

1. **NOTE:** **Make sure all cylinder head surfaces are clear of any gasket material, silicone sealant, oil and coolant. The cylinder head surface must be clean and dry before running a flatness check.**

NOTE: **Use a Straightedge that is calibrated by the manufacturer to be flat within 0.005 mm (0.0002 in) per running foot of length, such as Snap-On® GA438A or equivalent. For example, if the Straightedge is 61 cm (24 in) long, the machined edge must be flat within 0.010 mm (0.0004 in) from end to end.**

Using a Straightedge and a Feeler Gauge Set, inspect the cylinder head for flatness in the sequence shown in illustration.

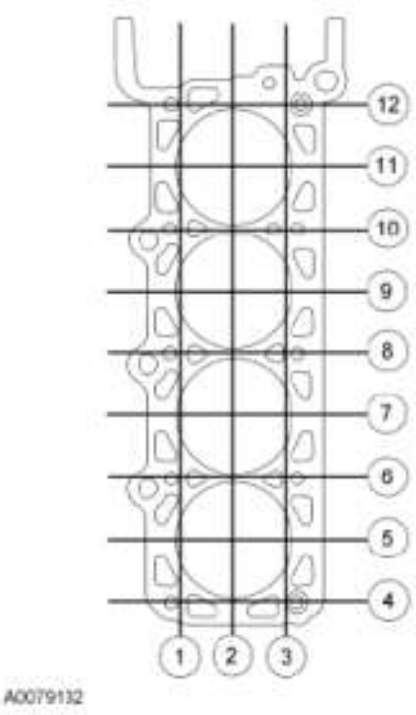
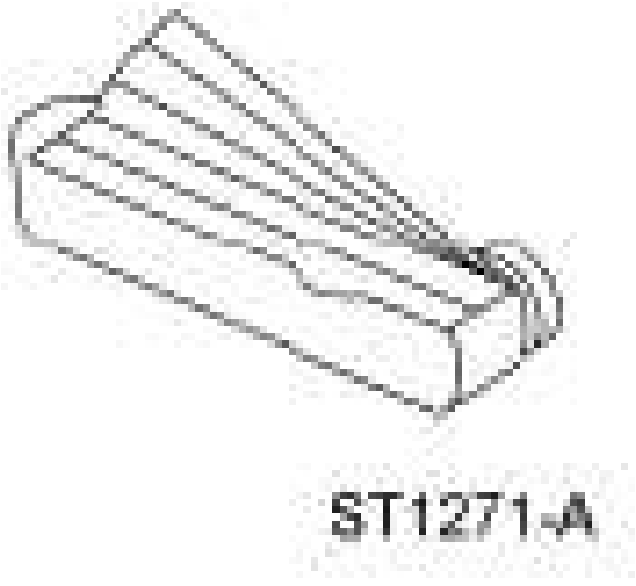


Fig. 56: Inspecting Cylinder Head
Courtesy of FORD MOTOR CO.

CYLINDER BLOCK DISTORTION

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

NOTE: **Refer to the appropriate ENGINE - 2.3L or ENGINE - 4.0L SOHC for the specification.**

NOTE: **Use a Straightedge that is calibrated by the manufacturer to be flat within 0.005 mm (0.0002 in) per running foot of length, such as Snap-On® GA438A or equivalent. For example, if the Straightedge is 61 cm (24 in) long, the machined edge must be flat within 0.010 mm (0.0004 in) from end to end.**

1. Use a Straightedge and a Feeler Gauge Set to inspect the cylinder block for flatness.

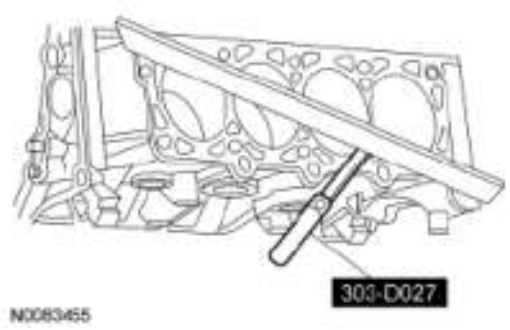


Fig. 57: Inspecting Cylinder Block For Flatness
Courtesy of FORD MOTOR CO.

CYLINDER BORE CLEANING

Material

MATERIAL SPECIFICATION

Item	Specification
Motorcraft® SAE 5W-20 Premium Synthetic Blend Motor Oil XO-5W20-QSP (US); Motorcraft® SAE 5W-20 Super Premium Motor Oil CXO-5W20-LSP12 (Canada); or equivalent	WSS-M2C930-A
Motorcraft® SAE 5W-30 Premium Synthetic Blend Motor Oil XO-5W30-QSP (US); Motorcraft® SAE 5W-30 Super Premium Motor Oil CXO-5W30-LSP12 (Canada); or equivalent	WSS-M2C929-A

NOTE: **If these procedures are not followed, rusting of the cylinder bores may occur.**

1. Clean the cylinder bores with soap or detergent and water.
2. Thoroughly rinse with clean water and wipe dry with a clean, lint-free cloth.
3. Use a clean, lint-free cloth and lubricate the cylinder bores.
   - Use clean engine oil.

CORE PLUG REPLACEMENT

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Slide Hammer 100-001 (T50T-100-A)

Material

MATERIAL SPECIFICATION

Item	Specification
High Temperature Retaining Compound Loctite® 620™/Permatex® 62050, or equivalent; obtain locally	WSK-M2G349-A9
Threadlock 262 TA-26	WSK-M2G351-A6

NOTE: It is necessary to use Loctite® Retaining Compound 620 High Temperature sealant on all 3 valve modular engine cylinder head cup plugs. If not used, the cylinder head cup plugs could leak or seep, causing serious engine damage.

NOTE: Use threadlock 262 on all other applications.

All core plugs

NOTE: Cylinder block core plug shown in illustration, cylinder head core plug similar.

1. Use the Slide Hammer and a freeze plug remover to remove the core plug.

Fig. 58: Removing Core Plug
Courtesy of FORD MOTOR CO.

2. **NOTE: Oversize plugs are identified by the OS stamped in the flat located on the cup side of the plug.**

Inspect the core plug bore for any damage that would interfere with the correct sealing of the plug. If the core plug bore is damaged, bore for the next oversize plug.

Cup-type

3. **NOTE: Use care during this procedure so as not to disturb or distort the cup sealing surface.**

NOTE: When installed, the flanged edge must be below the chamfered edge of the bore to effectively seal the bore.

Coat the cup-type core plug and bore lightly with sealant and install the core plug using a freeze plug installer.

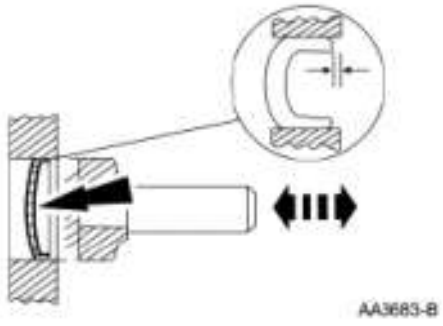


Fig. 59: Installing Core Plug Using Freeze Plug Installer - Cup-Type
Courtesy of FORD MOTOR CO.

Expansion-type

4. **NOTE: Do not contact the crown when installing an expansion-type core plug. This could expand the plug before seating and result in leakage.**

Coat the expansion-type core plug and bore lightly with sealant and install the core plug using a freeze

plug installer.

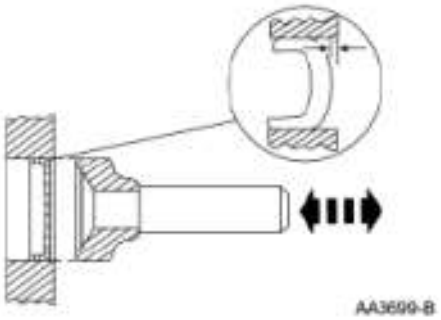


Fig. 60: Installing Core Plug Using Freeze Plug Installer - Expansion-Type
Courtesy of FORD MOTOR CO.

SPARK PLUG INSPECTION

1. Inspect the spark plug for a bridged gap.
    - Check for deposit build-up closing the gap between the electrodes. Deposits are caused by oil or carbon fouling.
    - Install a new spark plug.

Fig. 61: Identifying Spark Plug For Bridged Gap
Courtesy of FORD MOTOR CO.

2. Check for oil fouling.
    - Check for wet, black deposits on the insulator shell bore electrodes, caused by excessive oil entering the combustion chamber through worn rings and pistons, excessive valve-to-guide clearance or worn or loose bearings.
    - Correct the oil leak concern.
    - Install a new spark plug.

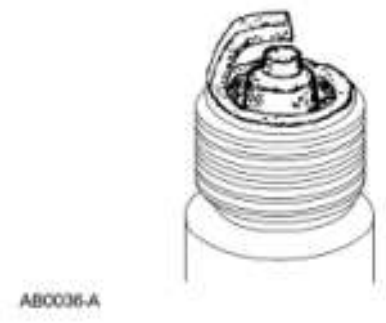


Fig. 62: Identifying Spark Plug For Oil Fouling
Courtesy of FORD MOTOR CO.

3. Inspect for carbon fouling. Look for black, dry, fluffy carbon deposits on the insulator tips, exposed shell surfaces and electrodes, caused by a spark plug with an incorrect heat range, dirty air cleaner, too rich a fuel mixture or excessive idling.
    - Install new spark plugs.

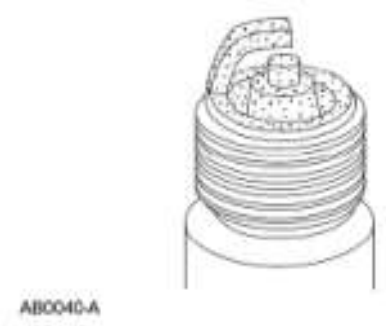


Fig. 63: Identifying Spark Plug For Carbon Fouling
Courtesy of FORD MOTOR CO.

4. Inspect for normal burning.
    - Check for light tan or gray deposits on the firing tip.

Fig. 64: Identifying Spark Plug For Normal Burning
Courtesy of FORD MOTOR CO.

5. Inspect for pre-ignition, identified by melted electrodes and a possibly damaged insulator. Metallic deposits on the insulator indicate engine damage. This may be caused by incorrect ignition timing, wrong type of fuel or the unauthorized installation of a heli-coil insert in place of the spark plug threads.
    - Install a new spark plug.

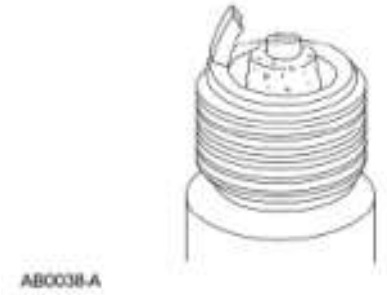


Fig. 65: Identifying Spark Plug Damaged Area
Courtesy of FORD MOTOR CO.

6. Inspect for overheating, identified by white or light gray spots and a bluish-burnt appearance of electrodes. This is caused by engine overheating, wrong type of fuel, loose spark plugs, spark plugs with an incorrect heat range, low fuel pump pressure or incorrect ignition timing.
    - Install a new spark plug.

Fig. 66: Identifying Spark Plug For Overheating
Courtesy of FORD MOTOR CO.

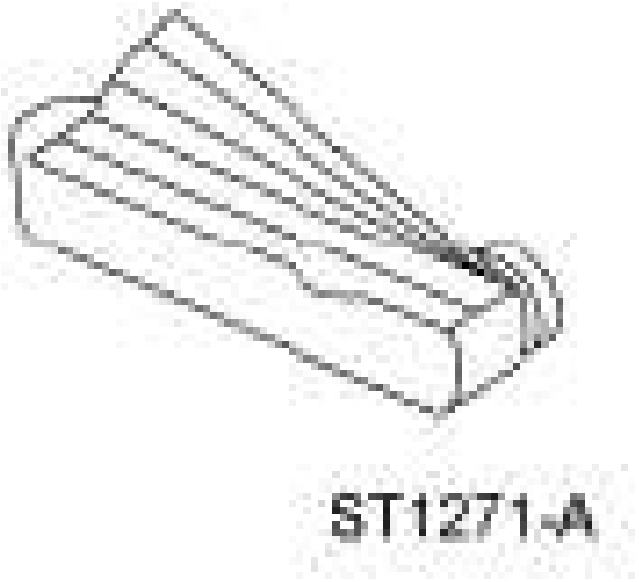
7. Inspect for fused deposits, identified by melted or spotty deposits resembling bubbles or blisters. These are caused by sudden acceleration.
    - Install new spark plugs.

Fig. 67: Identifying Spark Plug For Fused Deposits
Courtesy of FORD MOTOR CO.

EXHAUST MANIFOLD CLEANING AND INSPECTION

Special Tool(s)

SPECIAL TOOL SPECIFICATION

	Feeler Gauge Set 303-D027 (D81L-4201-A) or equivalent

1. Clean the exhaust manifold using a suitable solvent. Use a plastic scraping tool to clean the gasket sealing surfaces.

NOTE: New exhaust manifold gaskets, studs, nuts and/or bolts must be installed when an exhaust manifold is serviced.

2.

NOTE: Use a Straightedge that is calibrated by the manufacturer to be flat within 0.005 mm (0.0002 in) per running foot of length, such as Snap-On® GA438A or equivalent. For example, if the Straightedge is 61 cm (24 in) long, the machined edge must be flat within 0.010 mm (0.0004 in) from end to end.

Using the Straightedge and a Feeler Gauge Set, check the exhaust manifold sealing surface for warpage. If the warpage is greater than 0.76 mm (0.0299 in), install a new exhaust manifold.

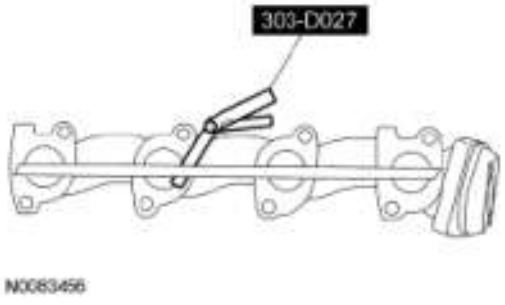


Fig. 68: Checking Exhaust Manifold Sealing Surface For Warpage
Courtesy of FORD MOTOR CO.

BEARING INSPECTION

1. Inspect bearings for the following defects:
    1. Cratering - fatigue failure

2. Spot polishing - incorrect seating
3. Imbedded dirty engine oil
4. Scratching - dirty engine oil
5. Base exposed - poor lubrication
6. Both edges worn - journal damaged
7. One edge worn - journal tapered or bearing not seated

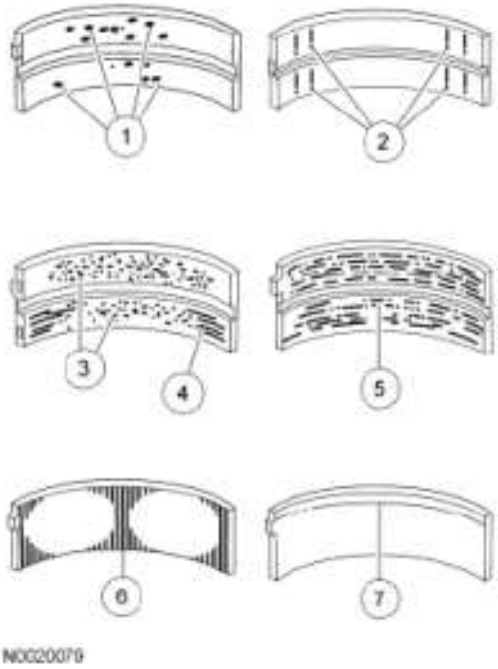


Fig. 69: Identifying Bearings For Defects Area
Courtesy of FORD MOTOR CO.

POWERTRAIN/DRIVETRAIN MOUNT NEUTRALIZING

NOTE: Refer to the appropriate service information and procedure for special instructions on loosening and tightening mount fasteners.

1. With the vehicle in NEUTRAL, position it on a hoist. For additional information, refer to **JACKING AND LIFTING** .
2. Loosen, but do not remove, the powertrain/drivetrain mount fasteners.
3. Lower the vehicle.

NOTE: Do not twist or strain the powertrain/drivetrain mounts or damage to the mounts may occur.

4. Start the vehicle and move it in forward 0.6-1.2 m (2-4 ft). Then move the vehicle in reverse the same distance.
5. Raise and support the vehicle.
6. Tighten the powertrain/drivetrain mount fasteners.
7. Lower the vehicle.

8. Test the system for normal operation.