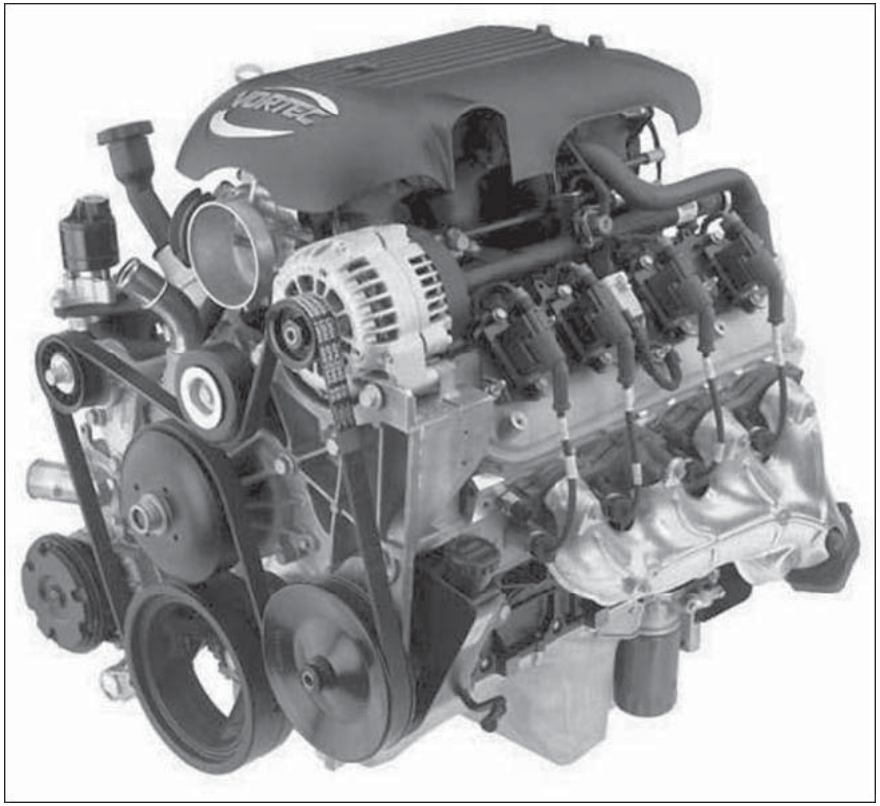
2007

ENGINE MECHANICAL



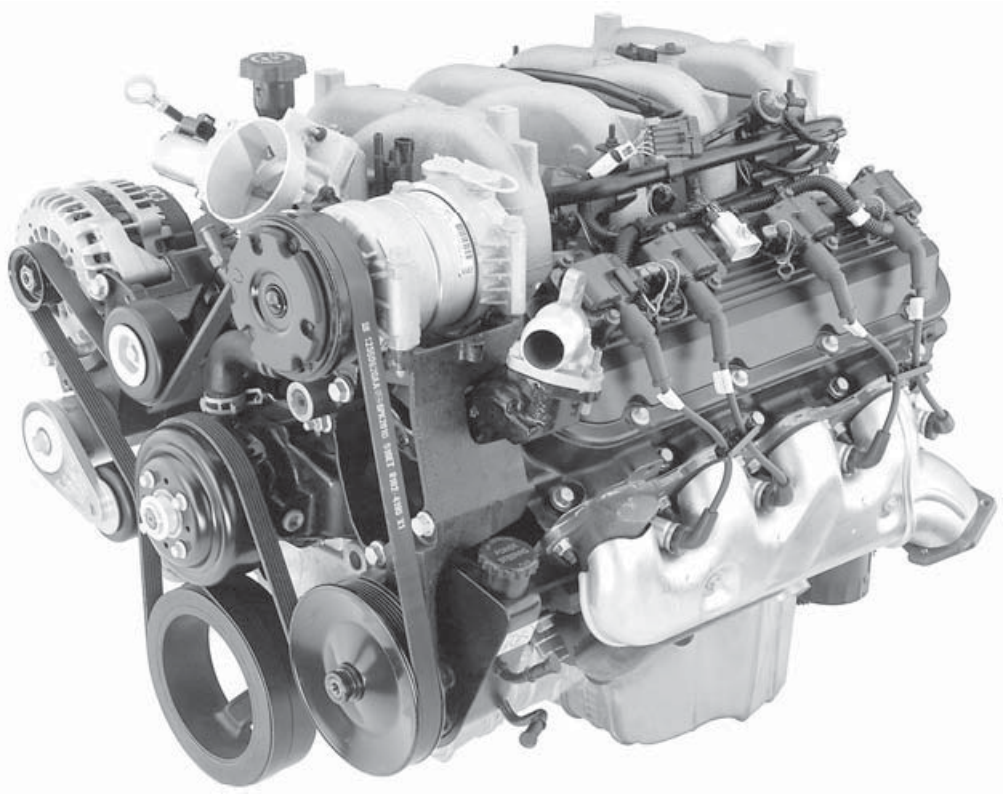


TABLE OF CONTENTS

8.1L (L18) ENGINE

FASTENER TIGHTENING SPECIFICATIONS L18 (8.1L) ENGINE Application	Specification	
	Metric	English
Air Cleaner Outlet Duct Clamp	4 N·m	35 lb in
Air Conditioning (A/C) Belt Tensioner Bolt	50 N·m	37 lb ft
Battery Cable Channel Bolt	9 N·m	80 lb in
Camshaft Position (CMP) Sensor Bolt	12 N·m	106 lb in
Camshaft Retainer Bolt	12 N·m	106 lb in
Camshaft Sprocket Bolt	30 N·m	22 lb ft
Connecting Rod Nut - First Pass	30 N·m	22 lb ft
Connecting Rod Nut - Final Pass	90 degrees	
Crankshaft Balancer Bolt	255 N·m	189 lb ft
Crankshaft Bearing Cap Bolts - First Pass	30 N·m	22 lb ft
Crankshaft Bearing Cap Bolts - Final Pass	90 degrees	
Crankshaft Bearing Cap Studs - First Pass	30 N·m	22 lb ft
Crankshaft Bearing Cap Studs - Final Pass	80 degrees	
Crankshaft Oil Deflector Nut	50 N·m	37 lb ft
Crankshaft Position (CKP) Sensor Bolt	12 N·m	106 lb in
Crossbar Bolt	100 N·m	74 lb ft
Cylinder Head Bolts - In Sequence		
• First Pass	30 N·m	22 lb ft
• Second Pass	30 N·m + 120 degrees	22 lb ft + 120 degrees
• Final Pass - Long Bolts #1, 2, 3, 6, 7, 8, 9, 10, 11, 14, 16, 17	60 degrees	
• Final Pass - Medium Bolts #15, 18	45 degrees	
• Final Pass - Short Bolts #4, 5, 12, 13	30 degrees	
Cylinder Head Coolant Hole Plug	50 N·m	37 lb ft
Drive Belt Idler Pulley Bolt	50 N·m	37 lb ft

Drive Belt Tensioner Bolt	50 N·m	37 lb ft
Engine Block Coolant Drain Hole M28 Plug - Left Front	60 N·m	44 lb ft
Engine Block Coolant Drain Hole Plug - Side	30 N·m	22 lb ft
Engine Block Coolant Heater	50 N·m	37 lb ft
Engine Block Oil Gallery Plug - Front	20 N·m	15 lb ft
Engine Block Oil Gallery Plug - Rear	30 N·m	22 lb ft
Engine Block Oil Gallery Plug - Side	30 N·m	22 lb ft
Engine Block Oil Gallery Plug - Top	20 N·m	15 lb ft
Engine Coolant Crossover Bolt	50 N·m	37 lb ft
Engine Coolant Temperature (ECT) Senso	50 N·m	37 lb ft
Engine Coolant Temperature (ECT) Sensor Bracket Bolt	50 N·m	37 lb ft
Engine Harness Bolt	5 N·m	44 lb in
Engine Harness Ground Bolt	16 N·m	12 lb ft
Engine Harness Stud	10 N·m	89 lb in
Engine Lift Bracket Bolt	40 N·m	30 lb ft
Engine Mount-to-Engine Bolt	50 N·m	37 lb ft
Engine Shield Bolt	20 N·m	15 lb ft
Engine Sight Shield Bracket Nut	5 N·m	44 lb in
Engine Wiring Harness Bolt	16 N·m	12 lb ft
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Bolt	8 N·m	71 lb in
Exhaust Gas Recirculation (EGR) Valve Opening Cover Nut	22 N·m	16 lb ft
Exhaust Gas Recirculation (EGR) Valve Opening Cover Stud	7 N·m	62 lb in
Exhaust Manifold Center Bolt	5 N·m	26 lb ft
Exhaust Manifold Nut	16 N·m	12 lb ft
Exhaust Manifold Stud	20 N·m	15 lb ft
Exhaust Manifold Heat Shield Bolt	25 N·m	18 lb ft
Exhaust Manifold Heat Shield Nut	25 N·m	18 lb ft
Flywheel Bolt - First Pass	40 N·m	30 lb ft
Flywheel Bolt - Second Pass	80 N·m	59 lb ft

Flywheel Bolt - Final Pass	100 N·m	74 lb ft
Front Cover Bolt - First Pass	6 N·m	53 lb in
Front Cover Bolt - Final Pass	12 N·m	106 lb in
Fuel Rail Bolt/Stud	12 N·m	106 lb in
Heater Hose Bracket Bolt	50 N·m	37 lb ft
Hood Hinge Bolt	25 N·m	18 lb ft
Ignition Coil Bolt	12 N·m	106 lb in
Ignition Coil Wiring Harness Bolt	12 N·m	106 lb in
Intake Manifold Bolts - First Pass In Sequence	5 N·m	44 lb in
Intake Manifold Bolts - Second Pass In Sequence	8 N·m	71 lb in
Intake Manifold Bolts - Third Pass In Sequence	12 N·m	106 lb in
Intake Manifold Bolt - Final Pass In Sequence	15 N·m	11 lb ft
J 36857 Bolt	40 N·m	30 lb ft
J 42847 Bolt	50 N·m	37 lb ft
Knock Sensor	20 N·m	15 lb ft
Knock Sensor Heat Shield Bolt	12 N·m	106 lb in
Manifold Absolute Pressure (MAP) Sensor Bolt	12 N·m	106 lb in
Oil Cooler Hose Fittings	23 N·m	17 lb ft
Oil Fill Tube Bolt	12 N·m	106 lb in
Oil Level Sensor	20 N·m	15 lb ft
Oil Pan Bolt - First Pass	10 N·m	89 lb in
Oil Pan Bolt - Final Pass	25 N·m	18 lb ft
Oil Pan Drain Plug	28 N·m	21 lb ft
Oil Pan Skid Plate Bolt	20 N·m	15 lb ft
Oil Pressure Sensor	30 N·m	22 lb ft
Oil Pump Bolt	75 N·m	56 lb ft
Oil Pump Cover Bolt	12 N·m	106 lb in
Oil Pump Drive Bolt	25 N·m	18 lb ft
Power Steering Pump Bracket Bolt/Nut	50 N·m	37 lb ft

Power Steering Pump Bracket Stud	20 N·m	15 lb ft
Spark Plug	30 N·m	22 lb ft
Throttle Body Nu	10 N·m	89 lb in
Throttle Body Stud	12 N·m	106 lb in
Valve Lifter Guide Retainer Bolt	25 N·m	18 lb ft
Valve Rocker Arm Cover Bolt - First Pass	6 N·m	53 lb in
Valve Rocker Arm Cover Bolt - Final Pass	12 N·m	106 lb in
Valve Rocker Arm Nut	35 N·m	26 lb ft
Valve Rocker Arm Stud	50 N·m	37 lb ft
Water Outlet Bolt/Stud	30 N·m	22 lb ft
Water Pump Bolt - First Pass	25 N·m	18 lb ft
Water Pump Bolt - Final Pass	50 N·m	37 lb ft
Water Pump Pulley Bolt	25 N·m	18 lb ft

ENGINE MECHANICAL SPECIFICATIONS L18 (8.1L) ENGINE L18 Engine Application	Specification	
	Metric	English
General		
• Engine Type	V8	
• Displacement	8.1L	496 CID
• RPO	L18	
• VIN - Light Duty	G	
• VIN - Medium Duty	G	
• Bore	107.95 mm	4.25 in
• Stroke	111.0 mm	4.37 in
• Compression Ratio	9.1:1	
• Firing Order	1-8-7-2-6-5-4-3	
• Spark Plug Gap	1.52 mm	0.06 in
Block		
• Crankshaft Main Bearing Bore Diameter	74.606-74.622 mm	2.9372-2.9379 in
• Cylinder Bore Diameter - Production	107.95-107.968 mm	4.25-4.2507 in
• Cylinder Bore Diameter - Service	107.94-107.99 mm	4.2496-4.2516 in
• Cylinder Bore Out-of-Round - Production, Maximum Minus Minimum Bore Diameter	0.018 mm	0.0007 in
• Cylinder Bore Out-of-Round - Service, Maximum Minus Minimum Bore Diameter	0.05 mm	0.002 in

• Cylinder Bore Taper - Production	0.018 mm	0.0007 in
• Cylinder Bore Taper - Service Thrust Axis	0.05 mm	0.002 in
• Cylinder Bore Taper - Service Pin Axis	0.05 mm	0.002 in
• Cylinder Head Deck Height - from Centerline of Crankshaft	259.875-260.125 mm	10.231-10.241 in
• Cylinder Head Deck Surface Flatness - Entire Face	0.1 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Within 150 mm (6 in)	0.05 mm	0.002 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft Bearing Inside Diameter	49.548-49.573 mm	1.9507-1.9517 in
• Camshaft Journal Diameter	49.472-49.522 mm	1.9477-1.9497 in
• Camshaft Lobe Lift - Exhaust	6.973-7.075 mm	0.2745-0.2785 in
• Camshaft Lobe Lift - Intake	6.924-7.026 m	0.2726-0.2766 in
• Camshaft Runout - Production	0.051 mm	0.002 in
• Camshaft Runout - Service	0.076 mm	0.003 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.033-0.068 mm	0.0013-0.0027 in
• Connecting Rod Bearing Clearance - Service	0.033-0.081 mm	0.0013-0.0032 in
• Connecting Rod Side Clearance	0.384-0.686 mm	0.0151-0.027 in
Crankshaft		
• Connecting Rod Journal Diameter	55.854-55.87 mm	2.199-2.1996 in

• Connecting Rod Journal Out-of-Round - Production	0.0102 mm	0.0004 in
• Connecting Rod Journal Taper - Production	0.0102 mm	0.0004 in
• Crankshaft End Play	0.127-0.35 mm	0.005-0.0138 in
• Crankshaft Main Bearing Clearance - #1, #2, #3, #4 Production	0.022-0.057 mm	0.0008-0.0022 in
• Crankshaft Main Bearing Clearance - #5 Production	0.034-0.069 mm	0.0013-0.0027 in
• Crankshaft Main Bearing Clearance - #1, #2, #3, #4 Service	0.022-0.089 mm	0.0008-0.0035 in
• Crankshaft Main Bearing Clearance - #5 Service Limit	0.035-0.102 mm	0.0014-0.004 in
• Crankshaft Main Journal Diameter	69.805-69.822 mm	2.7482-2.7489 in
• Crankshaft Main Journal Out-of-Round - Production	0.0102 mm	0.0004 in
• Crankshaft Main Journal Taper - Production	0.0102 mm	0.0004 in
• Crankshaft Runout - Production	0.05 mm	0.002 in
• Crankshaft Runout - Service	0.065 mm	0.0026 in
Cylinder Head		
• Cylinder Head Height/Thickness	259.875-260.125 mm	10.231-10.241 in
• Surface Flatness - Block Deck	0.05 mm	0.002 in
• Surface Flatness - Exhaust Manifold Deck	0.102 mm	0.004 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.003 in
Exhaust Mainfold		
• Surface Flatness	0.254 mm	0.01 in
Lubrication System		

• Oil Capacity - Without Filter	5.7L	6.0 Qts
• Oil Capacity - With Filter	6.15L	6.5 Qts
• Oil Pressure - Minimum	34 kPa @ 1,000 RPM	5 psi @ 1,000 RPM
• Oil Pressure - Minimum	69 kPa @ 2,000 RPM	10 psi @ 2,000 RPM
Piston Rings		
Piston Ring End Gap		
• First Compression Ring - Production	0.3-0.45 mm	0.012-0.018 in
• First Compression Ring - Service	0.45-0.675 mm	0.018-0.027 in
• Second Compression Ring - Production	0.45-0.65 mm	0.017-0.025 in
• Second Compression Ring - Service	0.675-0.975 mm	0.026-0.039 in
• Oil Control Ring - Production	0.249-0.759 mm	0.0098-0.0299 in
• Oil Control Ring - Service	0.373-1.138 mm	0.015-0.045 in
Piston Ring-to-Groove Clearance		
• First Compression Ring	0.031-0.074 mm	0.0012-0.0029 in
• Second Compression Ring	0.031-0.074 mm	0.0012-0.0029 in
• Oil Control Ring	0.051-0.203 mm	0.002-0.008 in
Piston and Pins		
Piston		
• Piston Diameter	Not Measurable	Not Measurable
• Piston-to-Bore Clearance	Interference Fit	Interference Fit

Pin		
• Pin-Piston Pin Fit in Connecting Rod Bore-Production	0.010-0.023 mm	0.0004-0.0009 in
• Pin-Piston Pin Fit in Connecting Rod Bore-Service	0.010-0.023 mm	0.0004-0.0009 in
• Pin-Piston Pin Clearance-to-Piston Pin Bore-Production	0.003-0.011 mm	0.00019-0.00043 in
• Pin-Piston Pin Clearance-to-Piston Pin Bore-Service	0.003-0.011 mm	0.00019-0.00043 in
• Pin-Piston Pin Diameter	26.416-26.419 mm	1.039-1.040 in
Valve System		
Valve		
• Valve Face Angle - Exhaust	45 degrees	
• Valve Face Angle - Intake	45 degrees	
• Valve Head Diameter - Exhaust	43.69 mm	1.72 in
• Valve Head Diameter - Intake	55.63 mm	2.19 in
• Valve Lash - Exhaust	Net Lash	Net Lash
• Valve Lash - Intake	Net Lash	Net Lash
• Valve Seat Angle - Exhaust	46 degrees	
• Valve Seat Angle - Intake	46 degrees	
• Valve Seat Runout - Exhaust	0.05 mm	0.002 in
• Valve Seat Runout - Intake	0.05 mm	0.002 in
• Valve Seat Width - Exhaust	1.651-2.159 mm	0.060-0.095 in
• Valve Seat Width - Intake	0.8-1.2 mm	0.03-0.06 in

• Valve Stem Diameter - Exhaust	9.431-9.449 mm	0.3713-0.372 in
• Valve Stem Diameter - Intake	9.436-9.454 mm	0.3715-0.3722 in
• Valve Stem-to-Guide Clearance - Exhaust - Production	0.03-0.079 mm	0.0012-0.0031 in
• Valve Stem-to-Guide Clearance - Intake - Production	0.025-0.074 mm	0.001-0.0029 in
• Valve Stem-to-Guide Clearance - Exhaust - Service	0.03-0.104 mm	0.0012-0.0041 in
• Valve Stem-to-Guide Clearance - Intake - Service	0.025-0.099 mm	0.001-0.0039 in
Rocker Arms		
• Valve Rocker Arm Ratio	1.7:1	
Valve Springs		
• Valve Spring Free Length	56.35 mm	2.218 in
• Valve Spring Installed Height	45.92-46.69 mm	1.808-1.838 in
• Valve Spring Load - Closed	381-419 N at 45.92 mm	86-94 lb at 1.808 in
• Valve Spring Load - Open	964-1056 N at 33.99 mm	216-236 lb at 1.338 in
•		

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL — (8.1L/ L18 ENGINE)

Begin the system diagnosis by reviewing the Disassembled Views, Engine Component Description , Lubrication Description , New Product Information , and the Drive Belt System Description. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to Symptoms - Engine Mechanical in order to identify the correct procedure for diagnosing the system and where the procedure is located.

Symptoms - Engine Mechanical

Strategy Based Diagnostics

Perform a Diagnostic System Check - Vehicle before using the symptom tables, if applicable.

Review the system operations in order to familiarize yourself with the system functions. Refer to Disassembled Views , Engine Component Description , Drive Belt System Description , Lubrication Description and New Product Information .

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary.

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to Checking Aftermarket Accessories.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the condition exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and ensure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Coolant in Combustion Chamber
- Coolant in Engine Oil
- Engine Compression Test
- Cylinder Leakage Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Drive Belt Chirping, Squeal, and Whine Diagnosis
- Drive Belt Rumbling and Vibration Diagnosis
- Drive Belt Falls Off and Excessive Wear Diagnosis

Cause	Correction
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire diagnostic trouble code (DTC). A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement - Accessory
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	1. Inspect the components. 2. Repair or replace the components, as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer, as required. Refer to Engine Flywheel Replacement or Crankshaft Balancer Replacement.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace, as required.
Improperly installed or damaged vacuum hoses	Repair or replace, as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body, as required.
Improperly installed or damaged manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor, as required.
Worn or loose rocker arms	Repair or replace the valve rocker arms, as required.

Worn or bent push rods	Replace the push rods.
Sticking valves Carbon buildup on the valve stem and/or seat can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain, camshaft retainer, and sprockets, as required
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection. 2. Perform a pressure test to the cooling system. Refer to Loss of Coolant . 3. Inspect the cylinder heads, engine block, and/or head gaskets. Refer to Coolant in Combustion Chamber . 4. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . 3. Perform cylinder leak down and compression testing to identify the cause. Refer to Cylinder Leakage Test . 4. Repair or replace, as required.

A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms, depending on the severity and location of the damage. • Systems with electronic communications, DIS, or coil per cylinder, and SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS, or coil per cylinder, and SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications and SEVERE reluctor ring damage may cause additional pulses and affect fuel and spark delivery to the point of generating a DTC P0300 or DTC P0336.	Replace the sensor and/or crankshaft reluctor wheel, as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms	Repair or replace the valve rocker arms, as required.
Worn or bent push rods	Replace the push rods.
Sticking valves Carbon buildup on the valve stem and/or seat can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain, camshaft retainer, and sprockets, as required
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace, as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection . 2. Perform a pressure test to the cooling system. Refer to Loss of Coolant . 3. Perform a cylinder leak down test. Refer to Cylinder Leakage Test . 4. Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to Coolant in Combustion Chamber . 5. Repair or replace, as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Leaking intake gaskets	Repair or replace the intake manifold bolts and/or gaskets, as required.
Worn valves, valve guides and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for loss of compression. Refer to Engine Compression Test . 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . 3. Perform cylinder leak down and compression testing to determine the cause. Refer to Cylinder Leakage Test . 4. Repair or replace, as required.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Incorrect oil level An oil level that is overfull causes aeration within the oil.	Add or remove oil, as required, to achieve the proper level.
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the valve lifters, as required.
Worn crankshaft thrust bearing	1. Inspect the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace, as required.
Damaged or faulty oil filter bypass valve	1. Inspect the oil filter bypass valve for proper operation. 2. Repair or replace, as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Plugged oil filter	Replace the oil filter.
Low oil pressure	1. Verify proper oil level. 2. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 3. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm stud, nut, or bolt. 2. Repair or replace, as required.
Worn valve rocker arm	Replace the valve rocker arm.
Worn pushrod guide plate	Replace, as required.
Bent or damaged push rod	1. Inspect the following components and replace, as required: • The valve rocker arm • The valve push rod • The valve lifter
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring.
Worn and/or damaged valve rotators	Replace the valve rotators, as required.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn camshaft lobes	1. Inspect the camshaft lobes. 2. Replace the camshaft and valve lifters, as required.
Worn valve guides or valve stems	1. Inspect the valves and valve guides. 2. Repair, as required.

Stuck valves Carbon on the valve stem or valve seat may cause the valve to stick.	1. Inspect the valves and valve guides. 2. Repair, as required 3. Use GM top engine cleaner GM P/N 1050002, (Canadian P/N 992872) to eliminate carbon deposits following manufacturers instructions

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Verify proper oil level. 2. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 3. Repair or replace damaged components, as required.
Worn accessory drive components Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace, as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to Detonation/Spark Knock .
Loose torque converter bolts - automatic transmission only	1. Inspect the torque converter bolts and flywheel. 2. Repair or replace, as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Damaged oil pan contacting the oil pump screen An oil pan that has been damaged may improperly position the oil pump screen, preventing proper oil flow to the oil pump.	1. Inspect the oil pan. 2. Inspect the oil pump screen. 3. Repair or replace, as required.
Oil pump screen loose, damaged, or restricted	1. Inspect the oil pump screen. 2. Repair or replace, as required
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair, as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and connecting rod. 2. Repair or replace, as required.
Excessive connecting rod bearing clearance	1. Inspect the following components: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals 2. Repair, as required.

Excessive crankshaft bearing clearance	1. Inspect the crankshaft bearings and crankshaft journals. 2. Repair, as required.
Incorrect piston, piston pin, and connecting rod installation Pistons must be installed with the mark, or dimple, on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins, and connecting rods are installed correctly. 2. Repair, as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to Detonation/Spark Knock .
Loose torque converter bolts or improperly installed torque converter - automatic transmission only	1. Inspect the torque converter bolts and flywheel. 2. Verify correct installation of the torque converter. 3. Repair, as required.
Cracked flywheel - automatic transmission	1. Inspect the flywheel bolts and flywheel. 2. Repair, as required.
Excessive connecting rod bearing clearance	1. Inspect the following components: • The connecting rod bearings • The connecting rods • The crankshaft 2. Repair, as required.
Excessive crankshaft bearing clearance	1. Inspect the following components: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore 2. Repair, as required

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component or starter motor	1. Remove the accessory drive belt or belts and/or starter motor. 2. Rotate the crankshaft by hand at the balancer or flywheel location.
Broken timing chain	1. Inspect the timing chain, gears, and crankshaft sprocket locating pin. 2. Repair, as required.
Seized camshaft	1. Inspect the camshaft and camshaft bearings. 2. Repair, as required.
Bent valve in cylinder head	1. Inspect the valves and cylinder heads. 2. Repair, as required.
Hydraulically locked cylinder: • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and inspect for fluid. 2. Inspect for a sticking fuel injector. 3. Inspect for broken head gaskets. 4. Inspect for a cracked engine block or cylinder head.
Seized automatic transmission torque converter	1. Remove the torque converter bolts. 2. Rotate the crankshaft by hand at the balancer or flywheel location.
Seized manual transmission	1. Disengage the clutch. 2. Rotate the crankshaft by hand at the balancer or flywheel location.
Material in cylinder: • Broken valve • Piston material • Foreign material	1. Inspect the cylinder and cylinder head for damaged components and/or foreign materials. 2. Repair or replace, as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and connecting rod bearings. 2. Repair, as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Repair, as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair, as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or a coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition, which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate . 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. Refer to Cylinder Leakage Test . 4. Inspect by performing a cylinder compression test. 2 cylinders side-by-side on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side .
Cracked cylinder head	Replace the cylinder head and gasket.
Improper sealing of exhaust valve guide-to-cylinder head	Replace the cylinder head and gasket.
Cracked engine block	Replace the components, as required.
Cylinder head or engine block porosity	Replace the components, as required.
Warped cylinder head	1. Machine the cylinder head to the proper flatness, if applicable. 2. Replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Machine the cylinder head to the proper flatness, if applicable.	Replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .

COOLANT IN ENGINE OIL

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil overfill condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition, which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed . 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. Refer to Cylinder Leakage Test . 3. Inspect by performing a cylinder compression test. 2 cylinders side-by-side on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side .
Cracked cylinder head	Replace the cylinder head and gasket.
Improper sealing of exhaust valve guide-to-cylinder head	Replace the cylinder head and gasket.
Cracked engine block	Replace the components, as required.
Cylinder head or engine block porosity	Replace the components, as required.
Warped cylinder head	1. Machine the cylinder head to the proper flatness, if applicable. 2. Replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Faulty external engine oil cooler	Replace the components, as required.

ENGINE COMPRESSION TEST

1. Disconnect the ignition coil wire harness connector at the front of the engine on the left cylinder bank and at the rear of the engine at the right cylinder bank.
2. Disconnect the fuel injector electrical harness connector at the rear of the intake manifold.
3. Remove all spark plugs.
4. Block the throttle plate wide open.
5. Charge the battery, if the battery is not fully charged.
6. Start with the compression gage at 0, then crank the engine through 4 compression strokes, 4 puffs.
7. Make the compression test the same for each cylinder. Record the reading.

The minimum compression in any 1 cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi), (1035 x 70% = 725) (150 x 70% = 105).

8. If some cylinders have low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole.

- Normal -- Compression builds up quickly and evenly to the specified compression for each cylinder.
- Piston Rings Leaking -- Compression is low on the first stroke, then compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
- Valves Leaking -- Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
- If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the 2 cylinders.

CYLINDER LEAKAGE TEST

Tools Required: J 35667-A Cylinder Head Leakdown Tester or equivalent

Important: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate 1 or more of the following conditions:

- Worn or burnt valves
- Broken valve springs
- Stuck valve lifters
- Incorrect valve lash
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the J 35667-A or equivalent.

Important: It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.

5. Apply shop air pressure to the J 35667-A and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:

- Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
- Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
- Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block, or a damaged cylinder head.
- Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

7.Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of greater than 0.95 liter (1 quart) of engine oil within 379 liters (100 gallons) of fuel used. However, during initial engine break-in periods 5 000-6 500 kilometers (3,000-4,000 miles) oil consumption may exceed 1.9 liters (2 quarts) or greater per 379 liters (100 gallons) of fuel used. The causes of excessive oil consumption include the following conditions:

- External oil leaks
  Tighten bolts and/or replace gaskets and oil seals, as necessary.
- Incorrect oil level or improper reading of the oil level indicator
  With the vehicle on a level surface, allow adequate drain down time and measure for the correct oil level.
- Improper oil viscosity
  Use recommended SAE viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Valve guides and/or valve stem oil seals worn, or the seal omitted
  Ream the guides and install oversize service valves and/or new valve stem oil seals.
- Piston rings broken, improperly installed, worn, or not seated properly
  Allow adequate time for the rings to seat and replace broken or worn rings, as necessary.
- Piston improperly installed or piston size is incorrectly selected

OIL PRESSURE DIAGNOSIS AND TESTING

With the vehicle on a level surface, allow adequate drain down time, 2-3 minutes, and measure for the proper engine oil level. An overfull oil level causes aeration within the oil.

Add the recommended grade engine oil GM P/N 12345610, (Canadian P/N 993193), or equivalent, and fill the crankcase until the oil level measures FULL on the oil level indicator.

Operate the engine and verify low or no oil pressure on the vehicle oil pressure gage or oil indicator lamp.

Listen for a noisy valve train or knocking noise.

Inspect for the following conditions:

- Engine oil diluted by moisture or unburned fuel mixtures
- Improper engine oil viscosity for the expected temperature
- Incorrect or faulty oil pressure gage sensor
- Incorrect or faulty oil pressure gage
- Plugged oil filter
- Malfunctioning oil filter bypass valve

Remove the oil pressure gage sensor or another engine block oil gallery plug.

Install an oil pressure gage and measure the engine oil pressure.

If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:

- Oil pump worn or dirty
- Malfunctioning oil pump pressure relief valve
- Oil pump screen loose, plugged, or damaged
- Excessive bearing clearance or worn bearings
- Cracked, porous, or restricted oil galleries
- Engine block oil gallery plugs missing or incorrectly installed
- Broken valve lifters

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6

6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 8
8	Use the J 28428-E high intensity black light kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: - Higher than recommended fluid levels - Higher than recommended fluid pressures - Plugged or malfunctioning fluid filters or pressure bypass valves - Plugged or malfunctioning engine ventilation system - Improperly tightened or damaged fasteners - Cracked or porous components - Improper sealants or gaskets, where required - Improper sealant or gasket installation - Damaged or worn gaskets or seals - Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK

11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to Step 1	System OK

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.

12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
15. This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
16. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
17. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.
19. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8

8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis . Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19

19	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DIAGNOSTIC AIDS

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.
5. Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.
9. Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.
11. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.

12. Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove - The separation of the drive belt - A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	**Important**: If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?\	Go to Symptoms - Engine Mechanical or Go to Vibration Analysis - Engine	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7

6	Clean the drive belt pulleys using a suitable wire brush. Reinstall the drive belts. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you correct the condition?	Go to Step 8	Go to Step 7
7	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	Go to Step 11
11	Inspect for a bent water pump shaft. Refer to Water Pump Replacement . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may of occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.
5. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

7. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.

13. The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.

14. The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.

15. This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement - Accessory or Drive Belt Tensioner Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids

12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you find this condition?	Go to Step 16	Go to Step 14
14	Inspect for the proper drive belt. Did you find this condition?	Go to Step 16	Go to Step 15
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the replacement?	o to Step 17	--
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	--

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms	Repair or replace the valve rocker arms, as required.
Worn or bent push rods	Replace the push rods.
Sticking valves Carbon buildup on the valve stem and/or seat can cause the valve to not close properly.	Repair or replace, as required
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain, camshaft retainer, and sprockets, as required
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace, as required.

CRANKCASE VENTILATION SYSTEM DESCRIPTION L18 (8.1L) ENGINE

The crankcase ventilation system utilizes a fixed orifice in the intake manifold and has no serviceable components so routine maintenance of the system is not required.

A closed crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. The air cleaner supplies the fresh air through a filter to the crankcase. The crankcase mixes the fresh air blow-by gases. This mixture then passes through a pipe/passage located in the intake manifold.

Crankcase Ventilation System Inspection/Diagnosis

A plugged positive crankcase ventilation (PCV) pipe/passage way may cause:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in the engine

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

DRIVE BELT SYSTEM DESCRIPTION

The drive belt system consists of the following components:

- The drive belt
- The drive belt tensioner
- The drive belt idler pulley
- The crankshaft balancer pulley
- The accessory drive component mounting brackets
- The accessory drive components
  - The power steering pump
  - The generator
  - The A/C compressor
  - The engine cooling fan
  - The water pump, if belt driven

The drive belt system may use 1 belt or 2 belts. The drive belt is thin so that it can bend backwards and has several ribs to match the grooves in the pulleys. The drive belts are made of different types of rubbers, chloroprene or EPDM, and have different layers or plys containing either fiber cloth or cords for reinforcement.

Both sides of the drive belt may be used to drive the different accessory drive components. When the back side of the drive belt is used to drive a pulley, the pulley is smooth.

The drive belt is pulled by the crankshaft balancer pulley across the accessory drive component pulleys. The spring loaded drive belt tensioner keeps constant tension on the drive belt to prevent the drive belt from slipping. The drive belt tensioner arm will move when loads are applied to the drive belt by the accessory drive components and the crankshaft.

The drive belt system may have an idler pulley, which is used to add wrap to the adjacent pulleys. Some systems use an idler pulley in place of an accessory drive component when the vehicle is not equipped with the accessory.

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
14. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
15. This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
16. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
17. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.
19. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Step	Action	Yes	No
.**Notice**: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8

8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis . Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition? Go to Step 20 Go to Diagnostic Aids	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19

19	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids
20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may of occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.
5. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.
7. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut , spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.
13. The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.
14. The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.
15. This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. **DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys.** **DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.**			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1.Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2.Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10

10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement - Accessory or Drive Belt Tensioner Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids
12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you find this condition?	Go to Step 16	Go to Step 14
14	Inspect for the proper drive belt. Did you find this condition?	Go to Step 16	Go to Step 15
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the replacement?	Go to Step 17	--
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	--

DRIVE BELT TENSIONER DIAGNOSIS

Notice: Allowing the drive belt tensioner to snap into the free position may result in damage to the tensioner.

Remove the drive belt(s). Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning.

Position a hex-head socket on the belt tensioner pulley bolt head.

Move the drive belt tensioner through its full travel.

- The movement should feel smooth.
- There should be no binding.
- The tensioner should return freely.

If any binding is observed, replace the drive belt tensioner(s). Refer to Drive Belt Tensioner Replacement - Accessory or Drive Belt Tensioner Replacement - Air Conditioning .

Install the drive belt(s). Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning .

ENGINE COMPONENT DESCRIPTION (LQ4/LR4)

Cylinder Block

The engine block is made of cast iron and it has 8 cylinders arranged in a 90 degree V shape with 4 cylinders in each bank. The engine block is a 1 piece casting with the cylinders encircled by coolant jackets.

Cylinder Head

The cylinder heads are made of cast iron and have parent metal intake valve guides and intake valve seats. The cast iron exhaust valve guides and powdered metal valve seats are pressed into the exhaust ports. A spark plug is located between the valves in the side of the cylinder head. The engine coolant crossover attaches to the front of each cylinder head.

Camshaft

A steel camshaft is supported by 5 bearings pressed into the engine block. The camshaft sprocket is mounted to the front of the camshaft and is driven by the crankshaft sprocket through the timing chain.

Motion from the camshaft is transmitted to the valves by hydraulic roller valve lifters, valve push rods, and ball-type rocker arms. Gear teeth are machined into the camshaft near the rear journal in order to drive a shaft assembly which operates the oil pump driveshaft. The camshaft position (CMP) sensor reads a circular target, half raised and half lowered, that is integral to the camshaft sprocket. The CMP sensor signal is used by the powertrain control module (PCM) for start-up only.

Crankshaft

The crankshaft is made of cast nodular iron. The crankshaft is supported by 5 crankshaft bearings. The crankshaft bearings are retained by the crankshaft bearing caps. The crankshaft bearing caps are machined with the engine block for proper alignment and clearance. The crankshaft bearing caps are each retained by 2 bolts and 2 studs. The number 5 crankshaft bearing at the rear of the engine block is the end thrust bearing. The 4 connecting rod journals, 2 rods per journal, are spaced 90 degrees apart. The crankshaft position (CKP) sensor reluctor ring is pushed onto the rear of the crankshaft. The CKP sensor reluctor is constructed of powdered metal. The reluctor ring has an interference fit onto the crankshaft and an internal keyway for correct positioning.

Pistons and Connecting Rods

The pistons are cast aluminum and use 2 compression rings and 1 3-piece oil control ring assembly. The piston pins are a full-floating design. The piston skirts are coated in order to create an interference fit into the cylinder bore. The connecting rods are forged steel and have precision insert type crankshaft bearings. The piston and pin are to be serviced as an assembly.

Valve Train

The valve train is a ball pivot type. Motion is transmitted from the camshaft through the hydraulic roller valve lifters and tubular valve push rods to the valve rocker arms. The valve rocker arm pivots on a ball in order to open the valve. The hydraulic roller valve lifters keep all parts of the valve train in constant contact. Each valve lifter acts as an automatic adjuster and maintains zero lash in the valve train. This eliminates the need for periodic valve adjustment. The valve rocker arm stud and nut retains the valve rocker arm and ball seat. The valve rocker arm stud is threaded into the cylinder head. The valve stem seal is pressed onto the valve guide of the cylinder head.

Intake Manifold

The intake manifold is a 1-piece cast aluminum design. The throttle body is attached to the front of the intake manifold. The fuel rail assembly with 8 separate fuel injectors is retained to the intake manifold by 4 studs. The fuel injectors are seated in their individual manifold bores with O-ring seals to provide sealing. A Manifold Absolute Pressure (MAP) sensor is mounted on the top of the intake manifold and sealed by an O-ring seal. The MAP sensor is held in place with a retainer bolt. The evaporative emission (EVAP) canister purge solenoid valve is located in the front of the intake manifold. The positive crankcase ventilation (PCV) system is internally cast into the intake manifold. There is no serviceable PCV valve. A splash shield is installed under the intake manifold. The shield prevents hot oil from contacting the bottom of the intake manifold.

Exhaust Manifold

The exhaust manifolds are constructed of cast stainless steel. The exhaust manifolds direct exhaust gases from the combustion chambers to the exhaust system.

LUBRICATION DESCRIPTION

The gear-type oil pump is driven through an extension driveshaft. The extension driveshaft is driven by the oil pump drive, which is gear driven by the camshaft. The oil is drawn from the oil pan through a pickup screen and tube, into the oil pump. Pressurized oil flows through the oil filter, into the oil cooler, back into the engine, up to the oil pressure gage port and rear crankshaft bearing, and is then distributed to the upper oil galleries. Oil must flow around the oil pump drive in order to reach the right side valve lifters properly. The oil is delivered through internal passages in order to lubricate camshaft and crankshaft bearings and to provide lash control in the hydraulic valve lifters. Oil is metered from the valve lifters through the valve push rods in order to lubricate the valve rocker arms and ball pivots. Oil returning to the oil pan from the cylinder heads and the front camshaft bearing, lubricates the camshaft timing chain and the crankshaft and the camshaft sprockets. There are two bypass valves located in the engine block, above the oil filter. The oil filter bypass valve and the oil cooler bypass valve.

If the oil filter becomes plugged, the pressurized oil is diverted around the top of the oil filter. The oil filter bypass valve is forced open, allowing the oil to continue on to the oil cooler and engine oil passages. No oil filtration occurs because the oil is not allowed into the oil filter.

If the oil cooler flow becomes blocked, either from a plugged oil cooler or blocked or kinked oil cooler line, the oil cooler bypass valve is forced open, allowing oil to flow directly into the engine oil passages. Oil does not flow into or out of the engine oil cooler.

If both the oil filter and the oil cooler are plugged, the pressurized oil is routed around the top of the oil filter, through the oil filter bypass valve, through the oil cooler bypass valve and directly into the engine oil passages. Lubrication still occurs, but the oil is not filtered or directed through the oil cooler.

SEPARATING PARTS

Important: Many internal engine components will develop specific wear patterns on their friction surfaces.

When disassembling the engine, internal components MUST be separated, marked or organized in a way to ensure reinstallation to original location and position.

Separate, mark, or organize the following components:

- Piston to the specific cylinder bore
- Piston rings to the piston
- Connecting rod to the crankshaft journal
- Connecting rod to the bearing cap
- Crankshaft and connecting rod bearings
- Camshaft and valve lifters
- Valve lifters, guides, pushrods, pivot supports and rocker arms
- Valve to the valve guide
- Valve spring and shim to the cylinder head location
- Engine block crankshaft bearing cap location and direction
- Oil pump drive and driven gears

REPLACING ENGINE GASKETS

Gasket Reuse and Applying Sealant

- Do not reuse any gasket unless specified.
- Gaskets that can be reused will be identified in the service procedure.
- Do not apply sealant to any gasket or sealing surface unless specified in the service procedure.

Separating Components

- Use a rubber mallet in order to separate the components.
- Bump the part sideways in order to loosen the components.
- Bumping of the component should be done at bends or reinforced areas of the component to prevent distortion of the components.

Cleaning Gasket Surfaces

- Use care to avoid gouging or scraping the sealing surfaces.
- Use a plastic or wood scraper in order to remove all the sealant from the components.
  - Do not use any other method or technique to remove the sealant or the gasket material from a part.
- Do not use abrasive pads, sand paper, or power tools to clean the gasket surfaces.
  - These methods of cleaning can cause damage to the component sealing surfaces.
  - Abrasive pads also produce a fine grit that the oil filter cannot remove from the engine oil.
  - This fine grit is an abrasive and can cause internal engine damage.

Assembling Components

- Assemble components using only the sealant (or equivalent) that is specified in the service procedure.
- Sealing surfaces must be clean and free of debris or oil.
- Specific components such as crankshaft oil seals or valve stem oil seals may require lubrication during assembly.
- Components requiring lubrication will be identified in the service procedure.
- Apply only the amount of sealant specified in the service procedure to a component.
- Do not allow the sealant to enter into any blind threaded holes, as the sealant may prevent the fastener from clamping properly or cause component damage when tightened.

Important: Do not overtighten the fasteners.

- Tighten the fasteners to the proper specifications.

USE OF ROOM TEMPERATURE VULCANIZING (RTV) AND ANAEROBIC SEALER

Sealant Types

Important: The correct sealant and amount of sealant must be used in the proper location in order to prevent oil leaks, coolant leaks, or the loosening of the fasteners. DO NOT interchange the sealants. Use only the sealant, or equivalent, as specified in the service procedure.

The following 2 major types of sealant are commonly used in engines:

- Aerobic room temperature vulcanizing (RTV) sealant
- Anaerobic sealant, which include the following:
  - Gasket eliminator
  - Pipe
  - Threadlock

RTV Sealant

Aerobic type RTV sealant cures when exposed to air. This type of sealant is used where 2 components, such as the intake manifold and the engine block, are assembled together.

Use the following information when using RTV sealant:

- Do not use RTV sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Any other surfaces where a different type of sealant is specified in the service procedure
- Always follow all safety recommendations and the directions that are on the RTV sealant container.
- Use a plastic or wood scraper in order to remove all RTV sealant from the plastic and aluminum components.

Notice: Refer to Sealant Notice in Cautions and Notices.

- The surfaces to be sealed must be clean and dry.
- Use an RTV sealant bead size as specified in the service procedure.
- Apply the RTV sealant bead to the inside of any bolt holes areas.
- Assemble the components while the RTV sealant is still wet to the touch, within 3 minutes. Do not wait for the RTV sealant to skin over.
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications. DO NOT overtighten the fasteners.

Gasket Eliminator Sealant

Anaerobic type gasket eliminator sealant cures in the absence of air. This type of sealant is used where 2 rigid components, such as castings, are assembled together. When 2 rigid components are disassembled and no sealant or gasket is readily noticeable, the 2 parts were probably assembled using an anaerobic type gasket eliminator sealant.

Use the following information when using gasket eliminator sealant:

- Always follow all safety recommendations and directions that are on the gasket eliminator sealant container.
- Apply a continuous bead of gasket eliminator sealant to 1 flange.

The surfaces to be sealed must be clean and dry.

Notice: Refer to Sealant Notice in Cautions and Notices.

- Apply the gasket eliminator sealant evenly to get a uniform thickness of the gasket eliminator sealant on the sealing surface.

  Important: Gasket eliminator sealed joint fasteners that are partially torqued and the gasket eliminator sealant allowed to cure more than 5 minutes, may result in incorrect shimming and sealing of the joint.
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications. DO NOT overtighten the fasteners.
- After properly tightening the fasteners, remove the excess gasket eliminator sealant from the outside of the joint.

Threadlock Sealant

Anaerobic type threadlock sealant cures in the absence of air. This type of sealant is used for threadlocking and sealing of bolts, fittings, nuts, and studs. This type of sealant cures only when confined between 2 close fitting metal surfaces.

Use the following information when using threadlock sealant:

- Always follow all safety recommendations and directions that are on the threadlock sealant container.
- The threaded surfaces to be sealed must be clean and dry.
- Apply the threadlock sealant as specified on the threadlock sealant container.

  Important: Fasteners that are partially torqued and then the threadlock sealant allowed to cure more than 5 minutes, may result in incorrect clamp load of assembled components.
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications. DO NOT overtighten the fasteners.

Pipe Sealant

Anaerobic type pipe sealant cures in the absence of air and remains pliable when cured. This type of sealant is used where 2 components are assembled together and require a leak proof joint.

Use the following information when using pipe sealant:

- Do not use pipe sealant in areas where extreme temperatures are expected. These areas include:
  - The exhaust manifold
  - The head gasket
  - Surfaces where a different sealant is specified
- Always follow all safety recommendations and the directions that are on the pipe sealant container.
- The surfaces to be sealed must be clean and dry.
- Use a pipe sealant bead of the size or quantity as specified in the service procedure.

Notice: Refer to Sealant Notice in Cautions and Notices.

- Apply the pipe sealant bead to the inside of any bolt hole areas.
- Apply a continuous bead of pipe sealant to 1 sealing surface.
- Tighten the fasteners in sequence, if specified, and to the proper torque specifications. DO NOT overtighten the fasteners.

4.8L/6.0 (LR4/LQ4) ENGINES

FASTENER TIGHTENING SPECIFICATIONS (LR4 VIN V/LR4 VIN U)

Application	Specification	
	Metric	English
Air Cleaner Outlet Duct Clamp Screw	7 N·m	62 lb in
Air Conditioning (A/C) Belt Tensioner Bolt	50 N·m	37 lb ft
Air Conditioning (A/C) Compressor Bolt	50 N·m	37 lb ft
Air Conditioning (A/C) Discharge Hose Bolt	16 N·m	12 lb ft
Air Conditioning (A/C) Suction Hose Bolt	16 N·m	12 lb ft
Auxiliary Heater Water Pump Bracket Bolt - RPO HP	15 N·m	11 lb ft
Battery Cable Channel Bolt	12 N·m	106 lb in
Battery Cable Junction Block Bracket Bolt - RPO HP2	9 N·m	80 lb in
Camshaft Position (CMP) Sensor Bolt	25 N·m	18 lb ft
Camshaft Retainer Bolt - Hex Head Bolt	25 N·m	18 lb ft
Camshaft Retainer Bolt - TORX® Head Bolt	15 N·m	11 lb ft
Camshaft Sprocket Bolts	35 N·m	26 lb ft
Clutch Pressure Plate Bolt	70 N·m	53 lb ft
Connecting Rod Bolts - First Pass	20 N·m	15 lb ft
Connecting Rod Bolts - Final Pass	75 degrees	
Coolant Temperature Sensor	20 N·m	15 lb ft
Crankshaft Balancer Bolt - Installation Pass - to Ensure the Balancer is Completely Installed	330 N·m	240 lb ft
Crankshaft Balancer Bolt - First Pass - Install a NEW Bolt After the Installation Pass and Tighten as Described in the First and Final Passes	50 N·m	37 lb ft
Crankshaft Balancer Bolt - Final Pass	140 degrees	
Crankshaft Bearing Cap M8 Bolts	25 N·m	18 lb ft
Crankshaft Bearing Cap M10 Bolts - First Pass in Sequence	20 N·m	15 lb ft
Crankshaft Bearing Cap M10 Bolts - Final Pass in Sequence	80 degrees	

Crankshaft Bearing Cap M10 Studs - First Pass in Sequence	20 N·m	15 lb ft
Crankshaft Bearing Cap M10 Studs - Final Pass in Sequence	51 degrees	
Crankshaft Oil Deflector Nut	25 N·m	18 lb ft
Crankshaft Position (CKP) Sensor Bolt	25 N·m	18 lb ft
Crossbar Bolt	100 N·m	74 lb ft
Cylinder Head M8 Bolts - in Sequence	30 N·m	22 lb ft
Cylinder Head M11 Bolts - First Pass in Sequence	30 N·m	22 lb ft
Cylinder Head M11 Bolts - Second Pass in Sequence	90 degrees	
Cylinder Head M11 Bolts - Final Pass in Sequence	70 degrees	
Cylinder Head Coolant Plug	20 N·m	15 lb ft
Differential Carrier Lower Mounting Bolt/Nut	100 N·m	74 lb ft
Drive Belt Idler Pulley Bolt	50 N·m	37 lb ft
Drive Belt Tensioner Bolt	50 N·m	37 lb ft
Engine Block Coolant Drain Hole Plug	60 N·m	44 lb ft
Engine Block Coolant Heater	50 N·m	37 lb ft
Engine Block Oil Gallery Plugs	60 N·m	44 lb ft
Engine Coolant Air Bleed Pipe and Cover Bolts	12 N·m	106 lb in
Engine Coolant Fitting - RPO HP2	35 N·m	26 lb ft
Engine Harness Ground Bolt - Right Rear	16 N·m	12 lb ft
Engine Harness Ground Bolt-to-Block	25 N·m	18 lb ft
Engine Mount Bolt	50 N·m	37 lb ft
Engine Mount Bracket Through Bolt	75 N·m	55 lb ft
Engine Mount-to-Engine Mount Bracket Bolt	65 N·m	50 lb ft
Engine Shield Bolt	20 N·m	15 lb ft
Engine Wiring Harness Bracket Nut	5 N·m	44 lb in
Evaporative Emission (EVAP) Canister Purge Solenoid Valve Bolt	10 N·m	89 lb in
Exhaust Manifold Bolts - First Pass	15 N·m	11 lb ft
Exhaust Manifold Bolts - Final Pass	25 N·m	18 lb ft
Exhaust Manifold Heat Shield Bolts	9 N·m	80 lb in
Flex Plate/Rotor Bolts - RPO HP2	100 N·m	74 lb ft

Flywheel Bolts - First Pass	20 N·m	15 lb ft
Flywheel Bolts - Second Pass	50 N·m	37 lb ft
Flywheel Bolts - Final Pass	100 N·m	74 lb ft
Front Cover Bolts	25 N·m	18 lb ft
Fuel Injection Fuel Rail Bolts	10 N·m	89 lb in
Fuel Rail Cover Bolt	9 N·m	80 lb in
Fuel Rail Crossover Tube Bolts	3.8 N·m	34 lb in
Fuel Rail Stop Bracket Bolt	50 N·m	37 lb ft
Generator Bracket Bolt	50 N·m	37 lb ft
Generator Cable Nut	9 N·m	80 lb in
Generator Coolant Inlet Hose Bolt - RPO HP2	10 N·m	89 lb in
Generator Coolant Outlet Pipe Stud - RPO HP	6 N·m	53 lb in
Heater Hose Bracket Nut	9 N·m	80 lb in
Hood Hinge Bolt	25 N·m	18 lb ft
Ignition Coil Bracket-to-Valve Rocker Arm Cover Stud	12 N·m	106 lb in
Ignition Coil-to-Bracket Bolts	10 N·m	89 lb in
Inner Axle Housing Nut	100 N·m	74 lb ft
Intake Manifold Bolts - First Pass in Sequence	5 N·m	44 lb in
Intake Manifold Bolts - Final Pass in Sequence	10 N·m	89 lb in
Intake Manifold Sight Shield Bolt	10 N·m	89 lb in
Intake Manifold Sight Shield Retainer Bolt	5 N·m	44 lb in
Intake Manifold Wiring Harness Stud	10 N·m	89 lb in
J 41712 M8 Bolt	25 N·m	18 lb ft
J 41712 M10 Bolts	50 N·m	37 lb ft
J 42286-A Bolt	50 N·m	37 lb ft
J 46093 Bolt	50 N·m	37 lb ft
Knock Sensors	20 N·m	15 lb ft
Oil Filter	30 N·m	22 lb ft
Oil Filter Fitting	55 N·m	40 lb ft
Oil Level Indicator Tube Bolt	25 N·m	18 lb ft

Oil Level Sensor	13 N·m	115 lb in
Oil Pan Baffle Bolts	12 N·m	106 lb in
Oil Pan Closeout Cover Bolt - Left Side	12 N·m	106 lb in
Oil Pan Closeout Cover Bolt - Right Side	12 N·m	106 lb in
Oil Pan Cover Bolts	12 N·m	106 lb in
Oil Pan Drain Plug	25 N·m	18 lb ft
Oil Pan M6 Bolts - Oil Pan-to-Rear Housing	12 N·m	106 lb in
Oil Pan M8 Bolts - Oil Pan-to-Engine Block and Oil Pan-to-Front Cover	25 N·m	18 lb ft
Oil Pan Skid Plate Bolt	20 N·m	15 lb ft
Oil Pressure Sensor	35 N·m	26 lb ft
Oil Pump Cover Bolts	12 N·m	106 lb in
Oil Pump Relief Valve Plug	12 N·m	106 lb in
Oil Pump Screen Nuts	25 N·m	18 lb ft
Oil Pump Screen-to-Oil Pump Bolt	12 N·m	106 lb in
Oil Pump-to-Engine Block Bolts	25 N·m	18 lb ft
Positive Battery Cable Clip Bolt	9 N·m	80 lb in
Power Steering Pump Bolt - RPO HP2	25 N·m	18 lb ft
Power Steering Pump Bracket Bolt - RPO HP2	25 N·m	18 lb ft
Power Steering Pump Harness Bolt - RPO HP2	25 N·m	18 lb ft
Power Steering Pump Harness Ground Bolt - RPO HP2	25 N·m	18 lb ft
Power Steering Pump Rear Bolt	50 N·m	37 lb ft
Rear Oil Seal Housing Bolts	30 N·m	22 lb ft
Spark Plugs	15 N·m	11 lb ft
Starter/Generator Control Module (SGCM) Cover Bolts - RPO HP2	9 N·m	80 lb in
Stator Stud - RPO HP2	16 N·m	12 lb ft
Throttle Body Nuts	10 N·m	89 lb in
Throttle Body Studs	6 N·m	53 lb in
Torque Converter Bolt - 4L60-E/4L65-E Transmissions	63 N·m	47 lb ft
Torque Converter Bolt - 4L80-E/4L85-E Transmissions	60 N·m	44 lb ft
Transmission Bolt/Stud	50 N·m	37 lb ft

Transmission Cover Bolt	12 N·m	106 lb in
Transmission Nut - RPO HP2	12 N·m	106 lb in
Transmission Oil Level Indicator Tube Nut	18 N·m	13 lb ft
Valley Cover Bolts	25 N·m	18 lb ft
Valve Lifter Guide Bolts	12 N·m	106 lb in
Valve Rocker Arm Bolts	30 N·m	22 lb ft
Valve Rocker Arm Cover Bolts	12 N·m	106 lb in
Water Inlet Housing Bolts	15 N·m	11 lb ft
Water Pump Bolts - First Pass	15 N·m	11 lb ft
Water Pump Bolts - Final Pass	30 N·m	22 lb ft

ENGINE MECHANICAL SPECIFICATIONS (LR4 VIN V)

Application	Specification	
	Metric	English
General		
• Bore	96.0-96.018 mm	3.779-3.78 in
• Compression Ratio	9.5:1	
• Displacement	4.8L	293 CID
• Engine Type	V8	
• Firing Order	1-8-7-2-6-5-4-3	
• RPO	LR4	
• Stroke	83.0 mm	3.268 in
• VIN	V	
• Spark Plug Gap	1.02 mm	0.04 in
Block		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.99-55.04 mm	2.164-2.166 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Exhaust	6.96 mm	0.274 in
• Camshaft Lobe Lift - Intake	6.82 mm	0.268 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
• Connecting Rod Journal Diameter - Production	53.318-53.338 mm	2.0991-2.0999 in
• Connecting Rod Journal Diameter - Service	53.308 mm	2.0987 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service	0.02 mm	0.00078 in
• Crankshaft End Play	0.04-0.2 mm	0.0015-0.0078 in
• Crankshaft Main Bearing Clearance - Production	0.02-0.052 mm	0.0008-0.0021 in
• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in

• Crankshaft Main Journal Diameter - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.003 mm	0.000118 in
• Crankshaft Main Journal Out-of-Round - Service	0.008 mm	0.0003 in
• Crankshaft Main Journal Taper - Production	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Service	0.02 mm	0.00078 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in
• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in
• Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
• Surface Flatness - Block Deck - Measured within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.13 mm	0.005 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.0031 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured within a 200 mm (7.87 in) Area that Includes 2 Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Capacity - with Filter	5.68 liters	6.0 quarts
• Oil Capacity - without Filter	4.73 liters	5.0 quarts
• Oil Pressure - Minimum - Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM

Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Rear Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.1 mm	0.0-0.004 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.23-0.44 mm	0.009-0.017 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.23-0.5 mm	0.009-0.0196 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.44-0.7 mm	0.017-0.027 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.44-0.76 mm	0.0173-0.03 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.18-0.75 mm	0.007-0.029 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.18-0.81 mm	0.007-0.032 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.04-0.085 mm	0.00157-0.00335 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.04-0.078 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.012-0.2 mm	0.0005-0.0078 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.012-0.2 mm	0.0005-0.0078 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.0004 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.943-0.943 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	96.002-96.036 mm	3.779-3.78 in
• Piston - Piston to Bore Clearance - Production	-0.036 to +0.016 mm	-0.0014 to +0.0006 in
• Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.071 mm	0.0028 in
• Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in
• Valves - Valve Lash	Net Lash - No Adjustment	

• Valves - Valve Lift - Exhaust	11.82 mm	0.465 in
• Valves - Valve Lift - Intake	11.58 mm	0.456 in
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in
• Valves - Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

ENGINE MECHANICAL SPECIFICATIONS (LQ4 VIN U)

Application	Specification	
	Metric	English
General		
• Bore	101.618-101.636 mm	4.0007-4.0014 in
• Compression Ratio	9.4:1	
• Displacement	6.0L	364 CID
• Engine Type	V8	
• Firing Order	1-8-7-2-6-5-4-3	
• RPO	LR4	
• Stroke	92.0 mm	3.622 in
• VIN	U	
• Spark Plug Gap	1.02 mm	0.04 in
Block		
• Camshaft Bearing Bore 1 and 5 Diameter	59.62-59.67 mm	2.347-2.349 in
• Camshaft Bearing Bore 2 and 4 Diameter	59.12-59.17 mm	2.327-2.329 in
• Camshaft Bearing Bore 3 Diameter	58.62-58.67 mm	2.307-2.309 in
• Crankshaft Main Bearing Bore Diameter	69.871-69.889 mm	2.75-2.751 in
• Crankshaft Main Bearing Bore Out-of-Round	0.006 mm	0.0002 in
• Cylinder Bore Diameter	101.618-101.636 mm	4.0007-4.0017 in
• Cylinder Head Deck Height - Measuring from the Centerline of Crankshaft to the Deck Face	234.57-234.82 mm	9.235-9.245 in
• Cylinder Head Deck Surface Flatness - Measured within a 152.4 mm (6.0 in) Area	0.11 mm	0.004 in
• Cylinder Head Deck Surface Flatness - Measuring the Overall Length of the Block Deck	0.22 mm	0.008 in
• Valve Lifter Bore Diameter	21.417-21.443 mm	0.843-0.844 in
Camshaft		
• Camshaft End Play	0.025-0.305 mm	0.001-0.012 in
• Camshaft Journal Diameter	54.99-55.04 mm	2.164-2.166 in
• Camshaft Journal Out-of-Round	0.025 mm	0.001 in
• Camshaft Lobe Lift - Exhaust	7.13 mm	0.281 in

• Camshaft Lobe Lift - Intake	6.96 mm	0.274 in
• Camshaft Runout - Measured at the Intermediate Journals	0.05 mm	0.002 in
Connecting Rod		
• Connecting Rod Bearing Clearance - Production	0.023-0.065 mm	0.0009-0.0025 in
• Connecting Rod Bearing Clearance - Service	0.023-0.076 mm	0.0009-0.003 in
• Connecting Rod Bore Diameter - Bearing End	56.505-56.525 mm	2.224-2.225 in
• Connecting Rod Bore Out-of-Round - Bearing End - Production	0.006 mm	0.0002 in
• Connecting Rod Bore Out-of-Round - Bearing End - Service	0.006 mm	0.0002 in
• Connecting Rod Side Clearance	0.11-0.51 mm	0.00433-0.02 in
Crankshaft		
• Connecting Rod Journal Diameter - Production	53.318-53.338 mm	2.0991-2.0999 in
• Connecting Rod Journal Diameter - Service	53.308 mm	2.0987 in
• Connecting Rod Journal Out-of-Round - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Out-of-Round - Service	0.01 mm	0.0004 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Production	0.005 mm	0.0002 in
• Connecting Rod Journal Taper - Maximum for 1/2 of Journal Length - Service	0.02 mm	0.00078 in
• Crankshaft End Play	0.04-0.2 mm	0.0015-0.0078 in
• Crankshaft Main Bearing Clearance - Production	0.02-0.052 mm	0.0008-0.0021 in
• Crankshaft Main Bearing Clearance - Service	0.02-0.065 mm	0.0008-0.0025 in
• Crankshaft Main Journal Diameter - Production	64.992-65.008 mm	2.558-2.559 in
• Crankshaft Main Journal Diameter - Service	64.992 mm	2.558 in
• Crankshaft Main Journal Out-of-Round - Production	0.003 mm	0.000118 in
• Crankshaft Main Journal Out-of-Round - Service	0.008 mm	0.0003 in
• Crankshaft Main Journal Taper - Production	0.01 mm	0.0004 in
• Crankshaft Main Journal Taper - Service	0.02 mm	0.00078 in
• Crankshaft Rear Flange Runout	0.05 mm	0.002 in
• Crankshaft Reluctor Ring Runout - Measured 1.0 mm (0.04 in) Below Tooth Diameter	0.7 mm	0.028 in
• Crankshaft Thrust Surface - Production	26.14-26.22 mm	1.029-1.0315 in
• Crankshaft Thrust Surface - Service	26.22 mm	1.0315 in

• Crankshaft Thrust Surface Runout	0.025 mm	0.001 in
Cylinder Head		
• Cylinder Head Height/Thickness - Measured from the Cylinder Head Deck to the Valve Rocker Arm Cover Seal Surface	120.2 mm	4.732 in
• Surface Flatness - Block Deck - Measured within a 152.4 mm (6.0 in) Area	0.08 mm	0.003 in
• Surface Flatness - Block Deck - Measuring the Overall Length of the Cylinder Head	0.1 mm	0.004 in
• Surface Flatness - Exhaust Manifold Deck	0.13 mm	0.005 in
• Surface Flatness - Intake Manifold Deck	0.08 mm	0.0031 in
• Valve Guide Installed Height - Measured from the Spring Seat Surface to the Top of the Guide	17.32 mm	0.682 in
Intake Manifold		
• Surface Flatness - Measured at Gasket Sealing Surfaces and Measured within a 200 mm (7.87 in) Area that Includes 2 Runner Port Openings	0.3 mm	0.118 in
Lubrication System		
• Oil Capacity - with Filter	5.68 liters	6.0 quarts
• Oil Capacity - without Filter	4.73 liters	5.0 quarts
• Oil Pressure - Minimum - Hot	41 kPa at 1,000 engine RPM 124 kPa at 2,000 engine RPM 165 kPa at 4,000 engine RPM	6 psig at 1,000 engine RPM 18 psig at 2,000 engine RPM 24 psig at 4,000 engine RPM
Oil Pan		
• Front Cover Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Rear Housing Alignment - at Oil Pan Surface	0.0-0.5 mm	0.0-0.02 in
• Oil Pan Alignment - to Rear of Engine Block at Transmission Bell Housing Mounting Surface	0.0-0.1 mm	0.0-0.004 in
Piston Rings		
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Production	0.31-0.52 mm	0.012-0.02 in
• Piston Ring End Gap - First Compression Ring - Measured in Cylinder Bore - Service	0.31-0.59 mm	0.0122-0.023 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Production	0.51-0.77 mm	0.02-0.03 in
• Piston Ring End Gap - Second Compression Ring - Measured in Cylinder Bore - Service	0.51-0.84 mm	0.02-0.033 in
• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Production	0.31-0.87 mm	0.0122-0.034 in

• Piston Ring End Gap - Oil Control Ring - Measured in Cylinder Bore - Service	0.31-0.94 mm	0.0122-0.037 in
• Piston Ring to Groove Clearance - First Compression Ring - Production	0.04-0.08 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - First Compression Ring - Service	0.04-0.08 mm	0.00157-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Production	0.039-0.079 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Second Compression Ring - Service	0.039-0.079 mm	0.0015-0.0031 in
• Piston Ring to Groove Clearance - Oil Control Ring - Production	0.015-0.199 mm	0.0006-0.0078 in
• Piston Ring to Groove Clearance - Oil Control Ring - Service	0.015-0.199 mm	0.0006-0.0078 in
Pistons and Pins		
• Pin - Piston Pin Clearance to Piston Pin Bore - Production	0.002-0.01 mm	0.00008-0.0004 in
• Pin - Piston Pin Clearance to Piston Pin Bore - Service	0.002-0.015 mm	0.00008-0.0006 in
• Pin - Piston Pin Diameter	23.952-23.955 mm	0.943-0.943 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Production	0.007-0.02 mm	0.00027-0.00078 in
• Pin - Piston Pin Fit in Connecting Rod Bore - Service	0.007-0.022 mm	0.00027-0.00086 in
• Piston - Piston Diameter - Measured Over Skirt Coating	101.606-101.640 mm	4.0002-4.0016 in
• Piston - Piston to Bore Clearance - Production	-0.022 to +0.03 mm - interference	-0.0009 to +0.0012 in - interference
• Piston - Piston to Bore Clearance - Service Limit with Skirt Coating Worn Off	0.071 mm	0.0028 in
• Valve System		
• Valves - Valve Face Angle	45 degrees	
• Valves - Valve Face Width	1.25 mm	0.05 in
• Valves - Valve Lash	Net Lash - No Adjustment	
• Valves - Valve Lift - Exhaust	12.11 mm	0.477 in
• Valves - Valve Lift - Intake	11.83 mm	0.466 in
• Valves - Valve Seat Angle	46 degrees	
• Valves - Valve Seat Runout	0.05 mm	0.002 in
• Valves - Valve Seat Width - Exhaust	1.78 mm	0.07 in
• Valves - Seat Width - Intake	1.02 mm	0.04 in
• Valves - Valve Stem Diameter - Production	7.955-7.976 mm	0.313-0.314 in
• Valves - Valve Stem Diameter - Service	7.95 mm	0.313 in

• Valves - Stem-to-Guide Clearance - Production - Intake	0.025-0.066 mm	0.001-0.0026 in
• Valves - Stem-to-Guide Clearance - Service - Intake	0.093 mm	0.0037 in
• Valves - Stem-to-Guide Clearance - Production - Exhaust	0.025-0.066 mm	0.001-0.0026 in
• Valves - Stem-to-Guide Clearance - Service - Exhaust	0.093 mm	0.0037 in
• Rocker Arms - Valve Rocker Arm Ratio	1.70:1	
• Valve Springs - Valve Spring Free Length	52.9 mm	2.08 in
• Valve Springs - Installed Height	45.75 mm	1.8 in
• Valve Springs - Valve Spring Load - Closed	340 N at 45.75 mm	76 lb at 1.8 in
• Valve Springs - Valve Spring Load - Open	980 N at 33.55 mm	220 lb at 1.32 in

ENGINE IDENTIFICATION

The vehicle identification number (VIN) is located on the left side rear of the engine block (1) and is typically a 9 digit number stamped or laser-etched onto the engine at the vehicle assembly plant.

- The first digit identifies the division.
- The second digit identifies the model year.
- The third digit identifies the assembly plant.
- The fourth through ninth digits are the last 6 digits of the VIN.

DIAGNOSTIC STARTING POINT - ENGINE MECHANICAL (LR4 VIN V & LQ4 VIN U)

Begin the system diagnosis by reviewing the Disassembled Views, Engine Component Description , Lubrication Description , New Product Information , and the Drive Belt System Description. Reviewing the description and operation information will help you determine the correct symptom diagnostic procedure when a malfunction exists. Reviewing the description and operation information will also help you determine if the condition described by the customer is normal operation. Refer to Symptoms - Engine Mechanical in order to identify the correct procedure for diagnosing the system and where the procedure is located.

Strategy Based Diagnostics

Perform a Diagnostic System Check - Vehicle before using the symptom tables, if applicable.

Review the system operations in order to familiarize yourself with the system functions. Refer to Disassembled Views , Engine Component Description , Drive Belt System Description , Lubrication Description and New Product Information .

All diagnosis on a vehicle should follow a logical process. Strategy based diagnostics is a uniform approach for repairing all systems. The diagnostic flow may always be used in order to resolve a system condition. The diagnostic flow is the place to start when repairs are necessary. For a detailed explanation, refer to Strategy Based Diagnosis .

Visual/Physical Inspection

- Inspect for aftermarket devices which could affect the operation of the engine. Refer to Checking Aftermarket Accessories.
- Inspect the easily accessible or visible system components for obvious damage or conditions which could cause the symptom.
- Inspect for the correct oil level, proper oil viscosity, and correct filter application.
- Verify the exact operating conditions under which the condition exists. Note factors such as engine RPM, ambient temperature, engine temperature, amount of engine warm-up time, and other specifics.
- Compare the engine sounds, if applicable, to a known good engine and ensure you are not trying to correct a normal condition.

Intermittent

Test the vehicle under the same conditions that the customer reported in order to verify the system is operating properly.

Symptom List

Refer to a symptom diagnostic procedure from the following list in order to diagnose the symptom:

- Base Engine Misfire without Internal Engine Noises
- Base Engine Misfire with Abnormal Internal Lower Engine Noises
- Base Engine Misfire with Abnormal Valve Train Noise
- Base Engine Misfire with Coolant Consumption
- Base Engine Misfire with Excessive Oil Consumption
- Engine Noise on Start-Up, but Only Lasting a Few Seconds
- Upper Engine Noise, Regardless of Engine Speed
- Lower Engine Noise, Regardless of Engine Speed
- Engine Noise Under Load
- Engine Will Not Crank - Crankshaft Will Not Rotate
- Coolant in Combustion Chamber
- Coolant in Engine Oil

- Engine Compression Test
- Cylinder Leakage Test
- Oil Consumption Diagnosis
- Oil Pressure Diagnosis and Testing
- Oil Leak Diagnosis
- Drive Belt Chirping, Squeal, and Whine Diagnosis
- Drive Belt Rumbling and Vibration Diagnosis
- Drive Belt Falls Off and Excessive Wear Diagnosis

BASE ENGINE MISFIRE WITHOUT INTERNAL ENGINE NOISES

Cause	Correction
Fuel injector harness connectors are connected to the incorrect fuel injectors/cylinders	Relocate the fuel injector harness connectors, as necessary.
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations and lead to a misfire diagnostic trouble code (DTC). A misfire code may be present without an actual misfire condition.	Replace the drive belt. Refer to Drive Belt Replacement - Accessory
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout May lead to a misfire A misfire code may be present without an actual misfire condition.	1. Inspect the components. 2. Repair or replace the components, as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer, as required. Refer to Engine Flywheel Replacement or Crankshaft Balancer Replacement.
Restricted exhaust system A severe restriction in the exhaust flow can cause significant loss of engine performance and may set a DTC. Possible causes of restrictions include collapsed or dented pipes or plugged mufflers and/or catalytic converters.	Repair or replace, as required.
Improperly installed or damaged vacuum hoses	Repair or replace, as required.
Improper sealing between the intake manifold and cylinder heads or throttle body	Replace the intake manifold, gaskets, cylinder heads, and/or throttle body, as required.
Improperly installed or damaged manifold absolute pressure (MAP) sensor The sealing grommet of the MAP sensor should not be torn or damaged.	Repair or replace the MAP sensor, as required.
Worn or loose rocker arms The rocker arm bearing end caps and/or neelde bearings should be intact and in the proper position.	Repair or replace the valve rocker arms, as required.
Worn or bent push rods	1. Replace the push rods. 2. Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.

Sticking valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Repair or replace the timing chain and sprockets, as required
Worn camshaft lobes	Replace the camshaft and valve lifters.
Excessive oil pressure A lubrication system with excessive oil pressure may lead to excessive valve lifter pump-up and loss of compression.	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing. 2. Repair or replace the oil pump, as required.
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Refer to Diagnostic Starting Point - Engine Cooling Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection. 2. Inspect the cylinder heads, engine block, and/or head gaskets. Refer to Coolant in Combustion Chamber . 3. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . 3. Perform cylinder leak down and compression testing to identify the cause. Refer to Cylinder Leakage Test . 4. Repair or replace, as required.

A damaged crankshaft reluctor wheel A damaged crankshaft reluctor wheel can result in different symptoms, depending on the severity and location of the damage. • Systems with electronic communications, DIS, or coil per cylinder, and SEVERE reluctor ring damage may exhibit periodic loss of crankshaft position, stop delivering a signal, and then re-sync the crankshaft position. • Systems with electronic communication, DIS, or coil per cylinder, and SLIGHT reluctor ring damage may exhibit no loss of crankshaft position and no misfire may occur. However, a DTC P0300 may be set. • Systems with mechanical communications and SEVERE reluctor ring damage may cause additional pulses and affect fuel and spark delivery to the point of generating a DTC P0300 or DTC P0336.	Replace the sensor and/or crankshaft as required.

BASE ENGINE MISFIRE WITH ABNORMAL INTERNAL LOWER ENGINE NOISES

Cause	Correction
Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt Abnormalities in the accessory drive system and/or components may cause engine RPM variations, noises similar to a faulty lower engine and also lead to a misfire condition. A misfire code may be present without an actual misfire	Replace the drive belt. Refer to Drive Belt Replacement - Accessory .
Worn, damaged, or mis-aligned accessory drive components or excessive pulley runout A misfire code may be present without an actual misfire condition.	1. Inspect the components. 2. Repair or replace the components, as required.
Loose or improperly installed engine flywheel or crankshaft balancer A misfire code may be present without an actual misfire condition.	Repair or replace the flywheel and/or balancer, as required. Refer to Engine Flywheel Replacement or Crankshaft Balancer Replacement.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . 3. Perform cylinder leak down and compression testing to determine the cause. Refer to Cylinder Leakage Test . 4. Repair or replace, as required.
Worn crankshaft thrust bearings Severely worn thrust surfaces on the crankshaft and/or thrust bearing may permit fore and aft movement of the crankshaft and create a DTC without an actual misfire condition.	Replace the crankshaft and bearings, as required.

BASE ENGINE MISFIRE WITH ABNORMAL VALVE TRAIN NOISE

Cause	Correction
Worn or loose rocker arms The rocker arm bearing end caps and/or needle bearings should be intact within the rocker arm assembly.	Replace the valve rocker arms, as required.
Worn or bent push rods	1. Replace the push rods. 2. Inspect the top of the pistons for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Sticking valves Carbon buildup on the valve stem can cause the valve to not close properly.	Repair or replace, as required.
Excessively worn or mis-aligned timing chain	Repair the timing chain and sprockets, as required
Worn camshaft lobes	Replace the camshaft and valve lifters.
Sticking lifters	Replace, as required.

BASE ENGINE MISFIRE WITH COOLANT CONSUMPTION

Cause	Correction
Faulty cylinder head gaskets and/or cracking or other damage to the cylinder heads and engine block cooling system passages Refer to Diagnostic Starting Point - Engine Cooling. Coolant consumption may or may not cause the engine to overheat.	1. Inspect for spark plugs saturated by coolant. Refer to Spark Plug Inspection . 2. Perform a cylinder leak down test. Refer to Cylinder Leakage Test . 3. Inspect the cylinder heads and engine block for damage to the coolant passages and/or a faulty head gasket. Refer to Coolant in Combustion Chamber . 4. Repair or replace, as required.

BASE ENGINE MISFIRE WITH EXCESSIVE OIL CONSUMPTION

Cause	Correction
Worn valves, valve guides, and/or valve stem oil seals	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Repair or replace, as required.
Worn piston rings Oil consumption may or may not cause the engine to misfire.	1. Inspect the spark plugs for oil deposits. Refer to Spark Plug Inspection . 2. Inspect the cylinders for a loss of compression. Refer to Engine Compression Test . 3. Perform cylinder leak down and compression testing to determine the cause. Refer to Cylinder Leakage Test . 4. Repair or replace, as required.

ENGINE NOISE ON START-UP, BUT ONLY LASTING A FEW SECONDS

Cause	Correction
Incorrect oil filter without anti-drainback feature	Install the correct oil filter.
Incorrect oil viscosity	1. Drain the oil. 2. Install the correct viscosity oil.
High valve lifter leak down rate	Replace the valve lifters, as required.
Worn crankshaft thrust bearing	1. Inspect the crankshaft end play. 2. Inspect the thrust bearing and crankshaft. 3. Repair or replace, as required.
Damaged or faulty oil filter bypass valve	1. Inspect the oil filter bypass valve for proper operation. 2. Repair or replace, as required.

UPPER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 2. Repair or replace, as required.
Loose and/or worn valve rocker arm attachments	1. Inspect the valve rocker arm stud, nut, or bolt. 2. Repair or replace, as required.
Worn or damaged valve rocker arm	1. Inspect the rocker arm for wear or missing needle bearings. 2. Replace the valve rocker arms, as required..
Worn pushrod guide plate	Replace, as required.
Bent or damaged push rod	1. Inspect the following components and replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The valve guide • The piston 2. Inspect the top of the piston for valve contact. If the top of the piston shows valve contact, replace the piston and pin assembly.
Improper lubrication to the valve rocker arms	Inspect the following components and repair or replace, as required: • The valve rocker arm • The valve push rod • The valve lifter • The oil filter bypass valve • The oil pump and pump screen • The engine block oil galleries
Broken valve spring	Replace the valve spring and spring shim.
Worn or dirty valve lifters	Replace the valve lifters.
Stretched or broken timing chain and/or damaged sprocket teeth	Replace the timing chain and sprockets.
Worn camshaft lobes	1. Inspect the camshaft lobes. 2. Replace the camshaft and valve lifters, as required.

Worn valve guides or valve stems	1. Inspect the valves and valve guides. 2. Repair, as required.
Stuck valves Carbon on the valve stem or valve seat may cause the valve to stick.	1. Inspect the valves and valve guides. 2. Repair, as required

LOWER ENGINE NOISE, REGARDLESS OF ENGINE SPEED

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 2. Repair or replace damaged components, as required.
Worn accessory drive components Abnormalities, such as severe cracking, bumps, or missing areas in the accessory drive belt and/or misalignment of system components.	1. Inspect the accessory drive system. 2. Repair or replace, as required.
Loose or damaged crankshaft balancer	1. Inspect the crankshaft balancer. 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls system. Refer to Detonation/Spark Knock .
Loose torque converter bolts - automatic transmission only	1. Inspect the torque converter bolts and flex plate. 2. Repair or replace, as required.
Loose or damaged flywheel	Repair or replace the flywheel.
Oil pump screen loose, damaged, or restricted	1. Inspect the oil pump screen. 2. Repair or replace, as required
Excessive piston-to-cylinder bore clearance	1. Inspect the piston and cylinder bore. 2. Repair, as required.
Excessive piston pin-to-bore clearance	1. Inspect the piston, piston pin, and connecting rod. 2. Repair or replace, as required.
Excessive connecting rod bearing clearance	1. Inspect the following components: • The connecting rod bearings • The connecting rods • The crankshaft • The crankshaft journals 2. Repair, as required.
Excessive crankshaft bearing clearance	1. Inspect the crankshaft bearings and crankshaft journals. 2. Repair, as required.
Incorrect piston, piston pin, and connecting rod installation Pistons must be installed with the mark, or dimple, on the top of the piston facing the front of the engine. Piston pins must be centered in the connecting rod pin bore.	1. Verify the pistons, piston pins, and connecting rods are installed correctly. Refer to Piston, Connecting Rod, and Bearing Installation. 2. Repair, as required.

ENGINE NOISE UNDER LOAD

Cause	Correction
Low oil pressure	1. Perform an oil pressure test. Refer to Oil Pressure Diagnosis and Testing . 2. Repair or replace, as required.
Detonation or spark knock	Verify the correct operation of the ignition controls. Refer to Detonation/Spark Knock .
Loose torque converter bolts	1. Inspect the torque converter bolts and flywheel. 2. Repair, as required.
Cracked flywheel - automatic transmission	1. Inspect the flywheel bolts and flywheel. 2. Repair, as required.
Excessive connecting rod bearing clearance	1. Inspect the following components: • The connecting rod bearings • The connecting rods • The crankshaft
Excessive crankshaft bearing clearance	1. Inspect the following components: • The crankshaft bearings • The crankshaft journals • The cylinder block crankshaft bearing bore
Loose or damaged RPO HP2 flex plate	Repair or replace the flex plate.
Loose or damaged RPO HP2 stator or rotor	1. Inspect the stator and rotor. 2. Repair or replace, as required.

ENGINE WILL NOT CRANK - CRANKSHAFT WILL NOT ROTATE

Cause	Correction
Seized accessory drive system component or starter motor	1. Remove the accessory drive belts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the balancer or flywheel location. 3. Repair or replace the components, as required.
Seized automatic transmission torque converter	1. Remove the torque converter-to-flywheel bolts. 2. Confirm that the engine will rotate. Rotate the crankshaft by hand at the crankshaft balancer or flywheel location. 3. Repair or replace the components, as required.
Broken timing chain	1. Inspect the timing chain, gears. 2. Repair or replace the components, as required.
Seized timing chain or timing gears	1. Inspect the timing chain and gears for foreign material or a seized chain. 2. Repair or replace the components, as required.
Seized or broken camshaft	1. Inspect the camshaft and camshaft bearings. 2. Repair or replace components, as required.
Bent valve in cylinder head	1. Inspect the valves and cylinder heads. 2. Repair or replace components, as required.
Seized oil pump	1. Inspect the oil pump assembly. 2. Repair or replace, as required.
Hydraulically locked cylinder: • Coolant/antifreeze in cylinder • Oil in cylinder • Fuel in cylinder	1. Remove the spark plugs and inspect for fluid in the cylinder. When rotating the eingine with the spark plutgs removed, the piston, on compression stroke, will push fluid from the combustion chamber. Refer to the Coolant in Combustion Chamber. 2. Inspect for failed/broken head gaskets. 3. Inspect for cracked engine block or cylinder head. 4. Inspect for a sticking fuel injector. 5. Repair or replace the components, as required.

Material in cylinder: • Broken valve • Broken piston rings • Piston material • Foreign material	1. Inspect the cylinder for damaged components and/or foreign materials. 2. Repair or replace the components, as required.
Seized crankshaft or connecting rod bearings	1. Inspect the crankshaft and connecting rod bearings. 2. Repair or replace the components, as required.
Bent or broken connecting rod	1. Inspect the connecting rods. 2. Replace the piston, pin, and connecting rod as an assembly, as required.
Broken crankshaft	1. Inspect the crankshaft. 2. Repair or replace the components, as required.
Seized RPO HP2 electric machine	1. Inspect the stator, rotor and flex plate. 2. Repair or replace, as required.

COOLANT IN COMBUSTION CHAMBER

Cause	Correction
DEFINITION: Excessive white smoke and/or a coolant type odor coming from the exhaust pipe may indicate coolant in the combustion chamber. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition, which may cause engine component damage. 1. A slower than normal cranking speed may indicate coolant entering the combustion chamber. Refer to Engine Will Not Crank - Crankshaft Will Not Rotate . 2. Remove the spark plugs and inspect for spark plugs saturated by coolant or coolant in the cylinder bore. 3. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the coolant may indicate a faulty gasket or damaged component. Refer to Cylinder Leakage Test . 4. Inspect by performing a cylinder compression test. 2 cylinders side-by-side on the engine block, with low compression, may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Cracked intake manifold or failed gasket	Replace the components, as required.
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side .
Warped cylinder head	1. Machine the cylinder head to the proper flatness, if applicable. 2. Replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components, as required.
Cylinder head or engine block porosity	Replace the components, as required.

COOLANT IN ENGINE OIL

Cause	Correction
DEFINITION: Foamy or discolored oil or an engine oil overfill condition may indicate coolant entering the engine crankcase. Low coolant levels, an inoperative cooling fan, or a faulty thermostat may lead to an overtemperature condition, which may cause engine component damage. Contaminated engine oil and oil filter should be changed. 1. Inspect the oil for excessive foaming or an overfill condition. Oil diluted by coolant may not properly lubricate the crankshaft bearings and may lead to component damage. Refer to Lower Engine Noise, Regardless of Engine Speed . 2. Inspect by performing a cylinder leak-down test. During this test, excessive air bubbles within the cooling system may indicate a faulty gasket or damaged component. Refer to Cylinder Leakage Test . 3. Inspect by performing a cylinder compression test. 2 cylinders side-by-side on the engine block with low compression may indicate a failed cylinder head gasket. Refer to Engine Compression Test .	
Faulty external engine oil cooler	Replace the components, as required.
Faulty cylinder head gasket	Replace the head gasket and components, as required. Refer to Cylinder Head Cleaning and Inspection and Cylinder Head Replacement - Left Side or Cylinder Head Replacement - Right Side .
Warped cylinder head	1. Machine the cylinder head to the proper flatness, if applicable. 2. Replace the cylinder head gasket. Refer to Cylinder Head Cleaning and Inspection .
Cracked cylinder head	Replace the cylinder head and gasket.
Cracked cylinder liner or engine block	Replace the components, as required.
Cylinder head block, or manifold porosity	Replace the components, as required.

ENGINE COMPRESSION TEST

1. Charge the battery if the battery is not fully charged.
2. Disable the ignition system.
3. Disable the fuel injection system.
4. Remove all the spark plugs.
5. Turn the ignition to the ON position.
6. Depress the accelerator pedal to position the throttle plate wide open.
7. Start with the compression gage at zero and crank the engine through 4 compression strokes, 4 puffs.
8. Measure the compression for each cylinder. Record the readings.
9. If a cylinder has low compression, inject approximately 15 ml (1 tablespoon) of engine oil into the combustion chamber through the spark plug hole. Measure the compression again and record the reading.
10. The minimum compression in any 1 cylinder should not be less than 70 percent of the highest cylinder. No cylinder should read less than 690 kPa (100 psi). For example, if the highest pressure in any 1 cylinder is 1 035 kPa (150 psi), the lowest allowable pressure for any other cylinder would be 725 kPa (105 psi). (1 035 x 70% = 725) (150 x 70% = 105).
    - Normal -- Compression builds up quickly and evenly to the specified compression for each cylinder.
    - Piston Rings Leaking -- Compression is low on the first stroke. Compression builds up with the following strokes, but does not reach normal. Compression improves considerably when you add oil.
    - Valves Leaking -- Compression is low on the first stroke. Compression usually does not build up on the following strokes. Compression does not improve much when you add oil.
    - If 2 adjacent cylinders have lower than normal compression, and injecting oil into the cylinders does not increase the compression, the cause may be a head gasket leaking between the cylinders.

CYLINDER LEAKAGE TEST

Tools Required

J 35667-A Cylinder Head Leakdown Tester or equivalent

Important: A leakage test may be performed in order to measure cylinder/combustion chamber leakage. High cylinder leakage may indicate 1 or more of the following conditions:

- Worn or burnt valves
- Broken valve springs
- Stuck valve lifters
- Incorrect valve lash
- Damaged piston
- Worn piston rings
- Worn or scored cylinder bore
- Damaged cylinder head gasket
- Cracked or damaged cylinder head
- Cracked or damaged engine block

Caution: Refer to Battery Disconnect Caution in Cautions and Notices.

1. Disconnect the battery ground negative cable.
2. Remove the spark plugs. Refer to Spark Plug Replacement .
3. Rotate the crankshaft to place the piston in the cylinder being tested at top dead center (TDC) of the compression stroke.
4. Install the J 35667-A or equivalent.

Important: It may be necessary to hold the crankshaft balancer bolt to prevent the crankshaft from rotating.

5. Apply shop air pressure to the J 35667-A and adjust according to the manufacturers instructions.
6. Record the cylinder leakage value. Cylinder leakage that exceeds 25 percent is considered excessive and may require component service. In excessive leakage situations, inspect for the following conditions:

- Air leakage sounds at the throttle body or air inlet hose that may indicate a worn or burnt intake valve or a broken valve spring.
- Air leakage sounds at the exhaust system tailpipe that may indicate a worn or burnt exhaust valve or a broken valve spring.
- Air leakage sounds from the crankcase, oil level indicator tube, or oil fill tube that may indicate worn piston rings, a damaged piston, a worn or scored cylinder bore, a damaged engine block, or a damaged cylinder head.
- Air bubbles in the cooling system may indicate a damaged cylinder head or a damaged cylinder head gasket.

7.Perform the leakage test on the remaining cylinders and record the values.

OIL CONSUMPTION DIAGNOSIS

Excessive oil consumption, not due to leaks, is the use of greater than 1l (1 quart) of engine oil within 3 200 Kilometers (2,000 Miles)

The causes of excessive oil consuption may include the following conditions:

- External oil leaks Refer to Oil Leak Diagnosis .
- Incorrect oil level or improper reading of the oil level indicator With the vehicle on a level surface, run the engine for a few minutes, allow adequate drain down time, 2-3 minutes, and check for the correct engine oil level.
- Improper oil viscosity Refer to the vehicle owners manual and use the recommended SAE grade and viscosity for the prevailing temperatures.
- Continuous high speed driving and/or severe usage
- Crankcase ventilation system restrictions or malfunctioning components
- Worn valve guides and/or valve stems
- Worn or improperly installed valve stem oil seals
- Piston rings broken, worn, or not seated properly Allow adequate time for the rings to seat. Replace worn piston rings as necessary.
- Piston and rings improperly installed or not fitted to the cylinder bore

OIL PRESSURE DIAGNOSIS AND TESTING

Tools Required

- EN-47971 Oil Pressure Gage Adapter
- J 21867 Pressure Gage

1. With the vehicle on a level surface, run the vehicle for a few minutes. Allow adequate drain down time, 2-3 minutes, and measure the oil level.
2. If required, add the recommended grade engine oil and fill the crankcase until the oil level measures full on the oil level indicator.
3. Run the engine briefly, 10-15 seconds, and verify low or no oil pressure on the vehicle gage or light.
4. Listen for a noisy valve train or a knocking noise.
5. Inspect for the following conditions:
   - Oil diluted by water or glycol antifreeze
   - Foamy oil
6. Remove the oil filter and install the EN-47971 (1).
7. Install the J 21867 (2), or equivalent to the EN-47971 (1).
8. Run the engine and measure the engine oil pressure.
8. Compare the readings to Engine Mechanical Specifications .
9. If the engine oil pressure is below specifications, inspect the engine for 1 or more of the following conditions:
   - Oil pump worn or dirty
   - Refer to Oil Pump Cleaning and Inspection .
   - Oil pump-to-engine block bolts loose
   - Refer to Oil Pump, Screen and Crankshaft Oil Deflector Installation .
   - Oil pump screen loose, plugged, or damaged
   - Oil pump screen O-ring seal missing or damaged
   - Malfunctioning oil pump pressure relief valve

- Excessive bearing clearance
- Cracked, porous, or restricted oil galleries
- Oil gallery plugs missing or incorrectly installed
- Refer to Engine Block Plug Installation .
- Broken valve lifters
- Repair as necessary.

10. If the oil pressure reading on the J 21867 , or equivalent, is within specifications, inspect for the following conditions:
    - Plugged or incorrect oil filter and/or malfunctioning oil bypass valve
    - The valve is now internal to the filter.
    - Malfunctioning oil pressure gage or sensor
    - Repair, as necessary.

OIL LEAK DIAGNOSIS

Step	Action	Yes	No
Important: You can repair most fluid leaks by first visually locating the leak, repairing or replacing the component, or by resealing the gasket surface. Once the leak is identified, determine the cause of the leak. Repair the cause of the leak as well as the leak itself.			
1	1. Operate the vehicle until it reaches normal operating temperature. 2. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 3. Wait 15 minutes. 4. Inspect for drippings. Are drippings present?	Go to Step 2	System OK
2	Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 3
3	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 4
4	1. Completely clean the entire engine and surrounding components. 2. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 3. Park the vehicle on a level surface, over a large sheet of paper or other clean surface. 4. Wait 15 minutes. 5. Identify the type of fluid, and the approximate location of the leak. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 5
5	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 6

6	1. Completely clean the entire engine and surrounding components. 2. Apply an aerosol-type powder, baby powder, foot powder, etc., to the suspected area. 3. Operate the vehicle for several kilometers, miles, at normal operating temperature and at varying speeds. 4. Identify the type of fluid, and the approximate location of the leak, from the discolorations in the powder surface. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 7
7	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 8
8	Use the J 28428-E high intensity black light kit in order to identify the type of fluid, and the approximate location of the leak. Refer to the manufacturer's instructions when using the tool. Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	Go to Step 9
9	1. Visually inspect the suspected area. Use a small mirror to assist in looking at hard to see areas. 2. Inspect for leaks at the following locations: - Sealing surfaces - Fittings - Cracked or damaged components Can you identify the type of fluid and the approximate location of the leak?	Go to Step 10	System OK
10	1. Inspect the engine for mechanical damage. Special attention should be shown to the following areas: - Higher than recommended fluid levels - Higher than recommended fluid pressures - Plugged or malfunctioning fluid filters or pressure bypass valves - Plugged or malfunctioning engine ventilation system - Improperly tightened or damaged fasteners - Cracked or porous components - Improper sealants or gaskets, where required - Improper sealant or gasket installation - Damaged or worn gaskets or seals - Damaged or worn sealing surfaces 2. Inspect the engine for customer modifications. Is there mechanical damage, or customer modifications to the engine?	Go to Step 11	System OK

11	Repair or replace all damaged or modified components. Does the engine still leak oil?	Go to Step 1	System OK

CRANKCASE VENTILATION SYSTEM INSPECTION/DIAGNOSIS LQ4/LR4 ENGINE

Crankcase Ventilation System Description

The crankcase ventilation system has no serviceable components so routine maintenance of the system is not required.

A closed crankcase ventilation system is used in order to provide a more complete scavenging of crankcase vapors. The air cleaner supplies the fresh air through a filter to the crankcase. The crankcase mixes the fresh air blow-by gases. This mixture then passes through a pipe/passage located in the intake manifold.

Crankcase Ventilation System Inspection/Diagnosis

A plugged positive crankcase ventilation (PCV) pipe/passage way may cause:

- Rough idle
- Stalling or slow idle speed
- Oil leaks
- Sludge in the engine

Symptom	Correction
External oil leak	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Damaged, incorrect, or incorrectly installed PCV hose • Excessive crankcase pressure
Rough Idle	Inspect for any of the following conditions: • Restricted or kinked PCV hose or engine vent hose • Leaking (damaged) PCV hose • Vacuum hoses worn or not properly installed
Stalling or slow idle speed	Inspect for any of the following conditions: • Restricted or kinked engine vent hose • Leaking (damaged) PCV hose
High idle speed	Inspect for a leaking (damaged) PCV hose
Sludge in the engine	Inspect for restricted or kinked PCV hose or engine vent hose

DRIVE BELT CHIRPING, SQUEAL, AND WHINE DIAGNOSIS

Diagnostic Aids

- A chirping or squeal noise may be intermittent due to moisture on the drive belts or the pulleys. It may be necessary to spray a small amount of water on the drive belts in order to duplicate the customers concern. If spraying water on the drive belt duplicates the symptom, cleaning the belt pulleys may be the probable solution.
- If the noise is intermittent, verify the accessory drive components by varying their loads making sure they are operated to their maximum capacity. An overcharged A/C system, power steering system with a pinched hose or wrong fluid, or a generator failing are suggested items to inspect.
- A chirping, squeal or whine noise may be caused by a loose or improper installation of a body or suspension component. Other items of the vehicle may also cause the noise.
- The drive belts will not cause a whine noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. The noise may not be engine related. This step is to verify that the engine is making the noise. If the engine is not making the noise do not proceed further with this table.
3. The noise may be an internal engine noise. Removing the drive belts one at a time and operating the engine for a brief period will verify the noise is related to the drive belt. When removing the drive belt the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspect all drive belt pulleys for pilling. Pilling is the small balls or pills or it can be strings in the drive belt grooves from the accumulation of rubber dust.
6. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
10. Inspecting of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed.
12. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.

14. This test is to verify that the drive belt tensioner operates properly. If the drive belt tensioner is not operating properly, proper belt tension may not be achieved to keep the drive belt from slipping which could cause a squeal noise.
15. This test is to verify that the drive belt is not too long, which would prevent the drive belt tensioner from working properly. Also if an incorrect length drive belt was installed, it may not be routed properly and may be turning an accessory drive component in the wrong direction.
16. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure for that pulley.
17. This test is to verify that the pulleys are the correct diameter or width. Using a known good vehicle compare the pulley sizes.
19. Replacing the drive belt when it is not damaged or there is not excessive pilling will only be a temporary repair.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The following items are indications of chirping: • A high pitched noise that is heard once per revolution of the drive belt or a pulley. • Chirping may occur on cold damp start-ups and will subside once the vehicle reaches normal operating temp. DEFINITION: The following items are indications of drive belt squeal: • A loud screeching noise that is caused by a slipping drive belt. This is unusual for a drive belt with multiple ribs. • The noise occurs when a heavy load is applied to the drive belt, such as an air conditioning compressor engagement snapping the throttle, or slipping on a seized pulley or a faulty accessory drive component. DEFINITION: The following items are indications of drive belt whine: • A high pitched continuous noise. • The noise may be caused by an accessory drive component failed bearing.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a chirping, squeal or whine noise. Does the engine make the chirping squeal or whine noise?	Go to Step 3	Go to Diagnostic Aids
3	1. Remove the drive belt. If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the chirping, squeal or whine noise still exist?	Go to Symptoms - Engine Mechanical	Go to Step 4
4	If diagnosing a chirping noise, inspect for severe pilling exceeding 1/3 of the belt groove depth. If diagnosing a squeal or whine noise, proceed to step 13. Do the belt grooves have pilling?	Go to Step 5	Go to Step 6
5	Clean the drive belt pulleys with a suitable wire brush. Did you complete the repair?	Go to Step 20	Go to Step 6
6	Inspect for misalignment of the pulleys. Are any of the pulleys misaligned?	Go to Step 7	Go to Step 8
7	Replace or repair any misaligned pulleys. Did you complete the repair?	Go to Step 20	Go to Step 8

8	Inspect for bent or cracked brackets. Did you find any bent or cracked brackets?	Go to Step 9	Go to Step 10
9	Replace any bent or cracked brackets. Did you complete the repair?	Go to Step 20	Go to Step 10
10	Inspect for improper, loose or missing fasteners. Did you find the condition?	Go to Step 11	Go to Step 12
11	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace any improper or missing fasteners. Did you complete the repair?	Go to Step 20	Go to Step 12
12	Inspect for a bent pulley. Did you find the condition?	Go to Step 18	Go to Step 19
13	Inspect for an accessory drive component seized bearing or a faulty accessory drive component. If diagnosing a whine noise and the condition still exist, proceed to Diagnostic Aids. Did you find and correct the condition?	Go to Step 20	Go to Step 14
14	Test the drive belt tensioner for proper operation. Refer to Drive Belt Tensioner Diagnosis . Did you find and correct the condition?	Go to Step 20	Go to Step 15
15	Inspect for the correct drive belt length. Did you find and correct the condition?	Go to Step 20	Go to Step 16
16	Inspect for misalignment of a pulley. Did you find and correct the condition?	Go to Step 20	Go to Step 17
17	Inspect for the correct pulley size. Did you find and correct the condition?	Go to Step 20	Go to Diagnostic Aids
18	Replace the bent pulley. Did you complete the repair?	Go to Step 20	Go to Step 19
19	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the repair?	Go to Step 20	Go to Diagnostic Aids

20	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT RUMBLING AND VIBRATION DIAGNOSIS

Diagnostic Aids

The accessory drive components can have an affect on engine vibration. Vibration from the engine operating may cause a body component or another part of the vehicle to make rumbling noise. Vibration can be caused by, but not limited to the air conditioning (A/C) system over charged, the power steering system restricted or the incorrect fluid, or an extra load on the generator. To help identify an intermittent or an improper condition, vary the loads on the accessory drive components.

The drive belt may have a rumbling condition that can not be seen or felt. Sometimes replacing the drive belt may be the only repair for the symptom.

If replacing the drive belt, completing the diagnostic table, and the noise is only heard when the drive belts are installed, there might be an accessory drive component with a failure. Varying the load on the different accessory drive components may aid in identifying which component is causing the rumbling noise.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This test is to verify that the symptom is present during diagnosing. Other vehicle components may cause a similar symptom.
3. This test is to verify that one of the drive belts is causing the rumbling noise or vibration. Rumbling noise may be confused with an internal engine noise due to the similarity in the description. Remove only one drive belt at a time if the vehicle has multiple drive belts. When removing the drive belts the water pump may not be operating and the engine may overheat. Also DTCs may set when the engine is operating with the drive belts removed.
4. Inspecting the drive belts is to ensure that they are not causing the noise. Small cracks across the ribs of the drive belt will not cause the noise. Belt separation is identified by the plys of the belt separating and may be seen at the edge of the belt our felt as a lump in the belt.
5. Small amounts of pilling is normal condition and acceptable. When the pilling is severe the drive belt does not have a smooth surface for proper operation.

9. Inspecting of the fasteners can eliminate the possibility that the wrong bolt, nut, spacer, or washer was installed.
11. This step should only be performed if the water pump is driven by the drive belt. Inspect the water pump shaft for being bent. Also inspect the water pump bearings for smooth operation and excessive play. Compare the water pump with a known good water pump.
12. Accessory drive component brackets that are bent, cracked, or loose may put extra strain on that accessory component causing it to vibrate.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The following items are indications of drive belt rumbling: • A low pitch tapping, knocking, or thumping noise heard at or just above idle. • Heard once per revolution of the drive belt or a pulley. • Rumbling may be caused from: - Pilling, the accumulation of rubber dust that forms small balls (pills) or strings in the drive belt pulley groove - The separation of the drive belt - A damaged drive belt DEFINITION: The following items are indications of drive belt vibration: • The vibration is engine-speed related. • The vibration may be sensitive to accessory load.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	Verify that there is a rumbling noise or that the vibration is engine related. Does the engine make the rumbling noise or vibration?	Go to Step 3	Go to Diagnostic Aids
3	**Important**: If the engine has multiple drive belts, remove the belts one at a time and perform the test below each time a belt is removed. 1. Remove the drive belt. 2. Operate the engine for no longer than 30-40 seconds. 3. Repeat this test if necessary by removing the remaining belt(s). Does the rumbling or vibration still exist?\	Go to Symptoms - Engine Mechanical or Go to Vibration Analysis - Engine	Go to Step 4
4	Inspect the drive belts for wear, damage, separation, sections of missing ribs, and debris build-up. Did you find any of these conditions?	Go to Step 7	Go to Step 5
5	Inspect for severe pilling of more than 1/3 of the drive belt pulley grooves. Did you find severe pilling?	Go to Step 6	Go to Step 7
6	Clean the drive belt pulleys using a suitable wire brush. Reinstall the drive belts. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you correct the condition?	Go to Step 8	Go to Step 7

7	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the replacement?	Go to Step 8	Go to Step 9
8	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 9
9	Inspect for improper, loose or missing fasteners. Did you find any of these conditions?	Go to Step 10	Go to Step 11
10	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace improper or missing fasteners. Did you complete the repair?	Go to Step 13	Go to Step 11
11	Inspect for a bent water pump shaft. Refer to Water Pump Replacement . Did you find and correct the condition?	Go to Step 13	Go to Step 12
12	Inspect for bent or cracked brackets. Did you find and correct the condition?	Go to Step 13	Go to Diagnostic Aids
13	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 3

DRIVE BELT FALLS OFF AND EXCESSIVE WEAR DIAGNOSIS

Diagnostic Aids

If the drive belt repeatedly falls off the drive belt pulleys, this is because of pulley misalignment.

An extra load that is quickly applied on released by an accessory drive component may cause the drive belt to fall off the pulleys. Verify the accessory drive components operate properly.

If the drive belt is the incorrect length, the drive belt tensioner may not keep the proper tension on the drive belt.

Excessive wear on a drive belt is usually caused by an incorrect installation or the wrong drive belt for the application.

Minor misalignment of the drive belt pulleys will not cause excessive wear, but will probably cause the drive belt to make a noise or to fall off.

Excessive misalignment of the drive belt pulleys will cause excessive wear but may also make the drive belt fall off.

Test Description

The numbers below refer to the step numbers on the diagnostic table.

2. This inspection is to verify the condition of the drive belt. Damage may of occurred to the drive belt when the drive belt fell off. The drive belt may of been damaged, which caused the drive belt to fall off. Inspect the belt for cuts, tears, sections of ribs missing, or damaged belt plys.
4. Misalignment of the pulleys may be caused from improper mounting of the accessory drive component, incorrect installation of the accessory drive component pulley, or the pulley bent inward or outward from a previous repair. Test for a misaligned pulley using a straight edge in the pulley grooves across two or three pulleys. If a misaligned pulley is found refer to that accessory drive component for the proper installation procedure of that pulley.
5. Inspecting the pulleys for being bent should include inspecting for a dent or other damage to the pulleys that would prevent the drive belt from not seating properly in all of the pulley grooves or on the smooth surface of a pulley when the back side of the belt is used to drive the pulley.
6. Accessory drive component brackets that are bent or cracked will let the drive belt fall off.

7. Inspection of the fasteners can eliminate the possibility that a wrong bolt, nut, spacer, or washer was installed. Missing, loose, or the wrong fasteners may cause pulley misalignment from the bracket moving under load. Over tightening of the fasteners may cause misalignment of the accessory component bracket.
13. The inspection is to verify the drive belt is correctly installed on all of the drive belt pulleys. Wear on the drive belt may be caused by mis-positioning the drive belt by one groove on a pulley.
14. The installation of a drive belt that is too wide or too narrow will cause wear on the drive belt. The drive belt ribs should match all of the grooves on all of the pulleys.
15. This inspection is to verify the drive belt is not contacting any parts of the engine or body while the engine is operating. There should be sufficient clearance when the drive belt accessory drive components load varies. The drive belt should not come in contact with an engine or a body component when snapping the throttle.

Step	Action	Yes	No
Notice: Refer to Belt Dressing Notice in Cautions and Notices. DEFINITION: The drive belt falls off the pulleys or may not ride correctly on the pulleys. DEFINITION: Wear at the outside ribs of the drive belt due to an incorrectly installed drive belt.			
1	Did you review the drive belt symptom operation and perform the necessary inspections?	Go to Step 2	Go to Symptoms - Engine Mechanical
2	• If diagnosing excessive wear, proceed to step 13. • If diagnosing a drive belt that falls off, inspect for a damaged drive belt. Did you find the condition?	Go to Step 3	Go to Step 4
3	Install a new drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 4	System OK
4	Inspect for misalignment of the pulleys. Did you find and repair the condition?	Go to Step 12	Go to Step 5
5	Inspect for a bent or dented pulley. Did you find and repair the condition?	Go to Step 12	Go to Step 6
6	Inspect for a bent or a cracked bracket. Did you find and repair the condition?	Go to Step 12	Go to Step 7
7	Inspect for improper, loose or missing fasteners. Did you find loose or missing fasteners?	Go to Step 8	Go to Step 9
8	**Notice**: Refer to Fastener Notice in Cautions and Notices. 1. Tighten any loose fasteners. Refer to Fastener Tightening Specifications . 2. Replace improper or missing fasteners. Does the drive belt continue to fall off?	Go to Step 9	System OK
9	Test the drive belt tensioner for operating correctly. Refer to Drive Belt Tensioner Diagnosis . Does the drive belt tensioner operate correctly?	Go to Step 11	Go to Step 10
10	Replace the drive belt tensioner. Refer to Drive Belt Tensioner Replacement - Accessory or Drive Belt Tensioner Replacement - Air Conditioning . Does the drive belt continue to fall off?	Go to Step 11	System OK
11	Inspect for failed drive belt idler and drive belt tensioner pulley bearings. Did you find and repair the condition?	Go to Step 12	Go to Diagnostic Aids

12	Operate the system in order to verify the repair. Did you correct the condition?	System OK	Go to Step 2
13	Inspect the drive belt for the proper installation. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you find this condition?	Go to Step 16	Go to Step 14
14	Inspect for the proper drive belt. Did you find this condition?	Go to Step 16	Go to Step 15
15	Inspect for the drive belt rubbing against a bracket, hose, or wiring harness. Did you find and repair the condition?	Go to Step 17	Go to Diagnostic Aids
16	Replace the drive belt. Refer to Drive Belt Replacement - Accessory or Drive Belt Replacement - Air Conditioning . Did you complete the replacement?	o to Step 17	--
17	Operate the system in order to verify the repair. Did you correct the condition?	System OK	--