SECTION : 1A

GENERAL ENGINE INFORMATION

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DIAGNOSIS

COMPRESSION TEST

Important : Disconnect the Crankshaft Position (CKP) Sensor connector to disable the fuel and the ignition systems.

Test the compression pressure for each cylinder. Low compression pressure may be the fault of the valves or the pistons. The following conditions should be considered when you check the cylinder compression:

- The engine should be at normal operating temperature.
- The throttle must be wide open.
- All the spark plugs should be removed.
- The battery must be at or near full charge.

1. Place approximately three squirts of oil from a plungertype oiler into each spark plug port.
2. Insert the engine compression gauge into each spark plug port.
3. Crank test each cylinder with four to five compression strokes using the starter motor.
4. The lowest reading should not be less than 70% of the highest reading. The compression gauge reading should not be less than 689 kPa (100 psi) for any of the cylinders.
5. Examine the gauge readings obtained after the four ”puffs” per cylinder are obtained from cranking the starter motor. The readings are explained in the following descriptions:

- Normal Condition – Compression builds up quickly and evenly to the specified compression on each cylinder.
- Piston Rings Faulty – Compression is low on the first stroke and tends to build up on following strokes, but the compression pressure does not reach normal. The compression pressure improves considerably with the addition of oil into the cylinder.
- Valves Faulty – Low compression pressure on the first stroke. The compression pressure does not tend to build up on the following strokes. The compression pressure does not improve much with the addition of oil into the cylinder.

OIL PRESSURE TEST

Step	Action	Value(s)	Yes	No
1	Is low or no oil pressure indicated?		Go to *Step 2*	System OK
2	Check the oil level in the crankcase. Is the oil level low?		Go to *Step 3*	Go to *Step 4*
3	Add oil so that the oil level is up to the fullmark on the indicator. Is the repair complete?		Go to *Step 1*	
4	Check the idle speed. Is the idle speed below the specified value ?	850 rpm	Go to *Step 5*	Go to *Step 6*
5	Increase the idle speed. Is the speed increased?		Go to *Step 1*	
6	Inspect the oil pressure switch. Is the oil pressure switch incorrect or malfunctioning?		Go to *Step 7*	Go to *Step 8*
7	Install a new oil pressure switch. Is the repair complete?		Go to *Step 1*	
8	Inspect the oil pressure gauge on instrument panel. Is the oil pressure gauge incorrect or malfunctioning?		Go to *Step 9*	Go to *Step 10*
9	Install a new oil pressure gauge. Is the repair complete?		Go to *Step 1*	
10	Inspect the engine oil. Is the engine oil in the crankcase diluted or of the improper viscosity?		Go to *Step 11*	Go to *Step 12*
11	Install new engine oil of the proper viscosity for the expected temperatures. Is the repair complete?		Go to *Step 1*	
12	Inspect the oil pump. Is the pump worn or dirty?		Go to *Step 13*	Go to *Step 14*
13	Replace the oil pump. Is the repair complete?		Go to *Step 1*	
14	Inspect the oil filter. Is the oil filter plugged?		Go to *Step 15*	*Step 16*
15	Install a new oil filter. Is the repair complete?		Go to *Step 1*	
16	Inspect the oil pickup screen. Is the oil pickup screen loose or plugged?		Go to *Step 17*	Go to *Step 18*
17	Tighten or replace the oil pickup screen, as necessary. Is the repair complete?		Go to *Step 1*	
18	Inspect the oil pickup tube. Are there any holes in the oil pickup tube?		Go to *Step 19*	Go to *Step 20*
19	Replace the oil pickup tube. Is the repair complete?		Go to *Step 1*	

Step	Action	Value(s)	Yes	No
20	Inspect the bearing clearances. Are the bearing clearances more than the specified values?	Crankshaft 0.040 mm (0.0016 in.) Connecting Rod 0.063 mm (0.0025 in.)	Go to *Step 21*	Go to *Step 22*
21	Replace the bearing, if necessary. Is the repair complete?		Go to *Step 1*	
22	Inspect the oil galleries. Are the oil galleries cracked, porous, or plugged?		Go to *Step 23*	Go to *Step 24*
23	Repair or replace the engine block. Is the repair complete?		Go to *Step 1*	
24	Inspect the gallery plugs. Are any of the gallery plugs missing or installed improperly?		Go to *Step 25*	Go to *Step 26*
25	Install the plugs or repair, as necessary. Is the repair complete?		Go to *Step 1*	
26	Inspect the camshaft. Is the camshaft worn or is there evidence of poor machining?		Go to *Step 27*	System OK
27	Replace the camshaft. Is the repair complete?		Go to *Step 1*	

OIL LEAK DIAGNOSIS

Most fluid oil leaks are easily located and repaired by visually finding the leak and replacing or repairing the necessary parts. On some occasions, a fluid leak may be difficult to locate or repair. The following procedures may help you in locating and repairing most leaks:

Finding the Leak

1. Identify the fluid. Determine whether it is engine oil, automatic transmission fluid, power steering fluid, etc.
2. Identify where the fluid is leaking from.
   1) After running the vehicle at normal operating temperature, park the vehicle over a large sheet of paper.
   2) Wait a few minutes.
   3) The drippings on the paper will lead to the approximate location of the leak.
3. Visually check around the suspected component. Check around all the gasket mating surfaces for leaks. A mirror is useful for finding leaks in areas that are hard to reach.
4. If the leak still cannot be found, it may be necessary to clean the suspected area with a degreaser, steam, or spray solvent.
   1) Thoroughly clean the area.
   2) Dry the area.
   3) Operate the vehicle for several miles at normal operating temperature and varying speeds.
   4) After operating the vehicle, visually check the suspected component.
   5) If the leak is not located, try using the powder or black light and dye method.

Powder Method

1. Clean the suspected area.
2. Apply an aerosol–type powder, (such as foot powder), to the suspected area.
3. Operate the vehicle under normal operating conditions.
4. Visually inspect the suspected component. Trace the leak path over the white powder surface to the source.

Black Light and Dye Method

A dye and light kit is available for finding leaks. Refer to the manufacturer’s directions when using the kit.

1. Pour the specified amount of dye into the engine oil fill tube.
2. Operate the vehicle under normal operating conditions, as directed in the kit.
3. Direct the light toward the suspected area. The dyed fluid will appear as a yellow path leading to the source.

Repairing the Leak

Once the origin of the leak has been pinpointed and traced back to its source, the cause of the leak must be determined for it to be repaired properly. If a gasket is replaced, but the sealing flange is bent, the new gasket will not repair the leak. The bent flange must be repaired also. Before attempting to repair a leak, check for the following conditions and correct them as they may cause a leak:

Gaskets

- The fluid level/pressure is too high.
- The crankcase ventilation system is malfunctioning.
- The fasteners are tightened improperly or the threads are dirty or damaged.
- The flanges or the sealing surface is warped.
- There are scratches, burrs, or other damage to the sealing surface.
- The gasket is damaged or worn.
- There is cracking or porosity of the component.
- An improper seal was used, (where applicable).

Seals

- The fluid level/pressure is too high.
- The crank case ventilation system is malfunctioning.
- The seal bore is damaged, scratched, burred or nicked.
- The seal is damaged or worn.
- Improper installation is evident.
- There are cracks in the component.
- The shaft surface is scratched, nicked or damaged.
- A loose or worn bearing is causing excess seal wear.

KNOCK DIAGNOSIS

Definition for Knock

Engine knock refers to various types of engine noise. Heavy knock is usually very loud and the result of broken or excessively worn internal engine components. Light knock is a noticeable noise, but not as loud. Light knock can be caused by worn internal engine components. Loose or broken external engine components can also cause heavy or light knock.

Engine Knocks Cold and Continues for Two–Three Minutes and/or Knock Increases with Engine Torque

Step	Action	Value(s)	Yes	No
1	Does the engine knock when it is cold and continue for two to three minutes or does the knock increase with torque?		Go to *Step 2*	System OK
2	Inspect the flywheel. Is the flywheel contacting the splash shield?		Go to *Step 3*	Go to *Step 4*
3	Reposition the splash shield. Is the repair complete?		Go to *Step 1*	
4	Inspect the balancer and the drive pulleys. Is either the balancer or the drive pulleys loose or broken?		Go to *Step 5*	Go to *Step 6*
5	Tighten or replace the balancer or the drive pulleys. Is the repair complete?		Go to *Step 1*	
6	Inspect the piston–to–bore clearance. Is the clearance more than the specified value?	0.030 mm (0.001 in.)	Go to *Step 7*	Go to *Step 8*
7	1. Rebore the cylinder and hone to size. 2. Replace the piston. Is the repair complete?*		Go to *Step 1*	
8	Inspect the connecting rod. Is the connecting rod bent?		Go to *Step 9*	System OK
9	Replace the connecting rod. Is the repair complete?		Go to *Step 1*	

* Cold engine piston knock usually disappears when the cylinder is grounded out. Cold engine piston knock, which disappears in about 1.5 minutes, is considered acceptable.

Heavy Knock Hot with Torque Applied

Step	Action	Value(s)	Yes	No
1	Is there a heavy knock when the engine is hot and torque is applied?		Go to *Step 2*	System OK
2	Inspect the balancer and the pulley hub. Is the balancer or the pulley hub broken?		Go to *Step 3*	Go to *Step 4*
3	Replace the broken balancer or the pulley hub. Is the repair complete?		Go to *Step 1*	
4	Inspect the torque converter bolts. Are the bolts tightened to specified value?	60 N•m(44 lb–ft)	Go to *Step 5*	Go to *Step 6*
5	Tighten the torque converter bolts. Is the repair complete?		Go to *Step 1*	
6	Inspect the accessory belts. Are the belts too tight or nicked?		Go to *Step 7*	*Step 8*
7	Replace and/or tension the belts to specifications, as necessary. Is the repair complete?		Go to *Step 1*	
8	Inspect the exhaust system. Is the system grounded?		Go to *Step 9*	Go to *Step 10*
9	Reposition the system, as necessary. Is the repair complete?		Go to *Step 1*	
10	Inspect the flywheel. Is the flywheel cracked?		Go to *Step 11*	Go to *Step 12*
11	Replace the flywheel. Is the repair complete?		Go to *Step 1*	
12	Inspect the main bearing clearance. Is the clearance more than the specified value?	0.040 mm (0.0016 in.)	Go to *Step 13*	Go to *Step 14*
13	Replace the main bearings, as necessary. Is the repair complete?		Go to *Step 1*	
14	Inspect the rod bearing clearance. Is the clearance more than the specified value?	0.063 mm (0.0025 in.)	Go to *Step 15*	System OK
15	Replace the rod bearings, as necessary. Is the repair complete?		Go to*Step 1*	

Light Knock Hot

Step	Action	Value(s)	Yes	No
1	Is there a light knock when the engine is hot?		Go to *Step 2*	System OK
2	Is detonation or spark knock evident?		Go to *Step 3*	Go to *Step 4*
3	Check the engine timing and the fuel quality. Was the problem found?		Go to *Step 1*	
4	Inspect the torque converter bolts. Are the bolts loose?		Go to *Step 5*	Go to *Step 6*
5	Tighten the torque converter bolts. Is the repair complete?		Go to *Step 1*	
6	Inspect the manifold. Is there an exhaust leak at the manifold?		Go to *Step 7*	Go to *Step 8*
7	Tighten the bolts or replace the gasket. Is the repair complete?		Go to *Step 1*	
8	Check the rod bearing clearance. Is the clearance within the specified value?	0.019–0.063 mm (0.0007–0.0024 in.)	Go to *Step 9*	System OK
9	Replace the rod bearings, as necessary. Is the repair complete?		Go to *Step 1*	

Knocks During Initial Start–Up But Lasts Only a Few Seconds

Step	Action	Value(s)	Yes	No
1	Does the engine knock during initial start–up but last only a few seconds?		Go to *Step 2*	System OK
2	Check the engine oil. Is the proper viscosity oil used in the crankcase?		Go to *Step 4*	Go to *Step 3*
3	Install oil of the proper viscosity for the expected seasonal temperatures. Is the repair complete?		Go to *Step 1*	
4	Inspect the hydraulic lifters. Is there evidence of hydraulic lifter bleed–down?		Go to *Step 5*	Go to *Step 6*
5	Clean, test and replace the lifters, as necessary. Is the repair complete?*		Go to *Step 1*	
6	Inspect the crankshaft end clearance. Is the clearance more than specified value?	0.302 mm (0.012 in.)	Go to *Step 7*	Go to *Step 8*
7	Replace the crankshaft thrust bearing. Is the repair complete?		Go to *Step 1*	
8	Inspect the front main bearing clearance. Is the clearance more than the specified value?	0.040 mm (0.0016 in.)	Go to *Step 9*	System OK
9	Replace the worn parts of the front main bearing. Is the repair complete?		Go to *Step 1*	

* When the engine is stopped, some valves will be open. Spring pressure against the lifters will tend to bleed the lifter down. Attempts to repair this should be made only if the problem is consistent.

An engine that is operated for only short periods between start–ups may have lifter noise that lasts for a few minutes. This is a normal condition.

Knocks at Idle Hot

Step	Action	Value(s)	Yes	No
1	Does the engine knock at idle when hot?		Go to *Step 2*	System OK
2	Inspect the drive belts. Are the belts loose or worn?		Go to *Step 3*	Go to *Step 4*
3	Tension or replace the belts, as necessary. Is the repair complete?		Go to *Step 1*	
4	Inspect the A/C compressor and the generator. Is either the compressor or the generator faulty?		Go to *Step 5*	Go to *Step 6*
5	Replace the faulty A/C compressor or the generator. Is the repair complete?		Go to *Step 1*	
6	Inspect the valve train. Are valve train components faulty?		Go to *Step 7*	Go to *Step 8*
7	Replace the faulty valve train components. Is the repair complete?		Go to *Step 1*	
8	Check the engine oil. Is the proper viscosity oil used in the crankcase?		Go to *Step 10*	Go to *Step 9*
9	Install oil of the proper viscosity for the expected seasonal temperatures. Is the repair complete?		Go to *Step 1*	
10	Inspect the piston pin clearance. Is the clearance more than the specified value?	0.014 mm (0.0005 in.)	Go to *Step 11*	Go to *Step 12*
11	Replace the piston and the pin. Is the repair complete?		Go to *Step 1*	
12	Check the connecting rod alignment. Is the alignment faulty?		Go to *Step 13*	Go to *Step 14*
13	Check and replace rods, as necessary. Is the repair complete?		Go to *Step 1*	
14	Inspect the piston–to–bore clearance. Is the clearance within the specified value?	0.03 mm (0.0012 in.)	Go to *Step 16*	Go to *Step 15*
15	Hone the bore and fit a new piston. Is the repair complete?		Go to *Step 1*	
16	Inspect the crankshaft balancer. Is the balancer loose?		Go to *Step 17*	Go to *Step 18*
17	Torque or replace worn parts. Is the repair complete?		Go to *Step 1*	
18	Check the piston pin offset. Is the offset at the specified value?	0.8 mm (0.031 in.) Toward Thrust Side	Go to *Step 19*	System OK
19	Install the correct piston. Is the repair complete?		Go to *Step 1*	

NOISE DIAGNOSIS

Main Bearing Noise

Step	Action	Value(s)	Yes	No
1	Are dull thuds or knocks heard with every engine revolution?		Go to *Step 2*	System OK
2	Check the oil pump pressure. Is the oil pump pressure low?		Go to*Oil Pressure Test*	Go to *Step 3*
3	Inspect the crankshaft end play. Is there excessive crankshaft end play?	0.070~0.302mm (0.0027~0.0119 in.)	Go to*Crankshaft Replacement Procedure*	Go to *Step 4*
4	Inspect the crankshaft journals. Are the crankshaft journals out–of–round?		Go to*Crankshaft Replacement Procedure*	Go to *Step 5*
5	Inspect the belt tension. Is there excessive belt tension?		Go to*Timing Belt Replacement Procedure*	Go to *Step 6*
6	Inspect the crankshaft pulley. Is the crankshaft pulley loose?		Go to*Crankshaft Replacement Procedure*	System OK

Connecting Rod Bearing Noise Symptom

Step	Action	Value(s)	Yes	No
1	Is a knock noise heard under all engine speeds?		Go to *Step 2*	System OK
2	Inspect the crankshaft connecting rod journal. Is the crankshaft connecting rod journal worn?		Go to*Crankshaft Replacement Procedure*	Go to *Step 3*
3	Check the oil pump pressure. Is the oil pump pressure low?		Go to*Oil Pressure Test*	Go to *Step 4*
4	Inspect the crankshaft connecting rod journals. Are the journals out–of–round?		Go to*Crankshaft Replacement Procedure*	Go to *Step 5*
5	Inspect the connecting rods. Is there a misaligned connecting rod?		Go to*Pistons and Rods Replacement Procedure*	Go to *Step 6*
6	Inspect the connecting rod bolts. Are the connecting rod bolts torqued properly?		System OK	Go to*Pistons and Rods Replacement Procedure*

Piston Noises

Step	Action	Value(s)	Yes	No
1	Are any of the following noises heard: a sharp double knock when the engine is idling, a light ticking with no load on the engine, or a ”slapping” noise when the engine is cold?		Go to *Step 2*	System OK
2	Inspect the piston pin and the bushing. Is the piston pin or the bushing worn or loose?		Go to*Pistons and Rods Replacement Procedure*	Go to *Step 3*
3	Inspect the piston. Is the piston broken or cracked?		Go to*Pistons and Rods Replacement Procedure*	Go to *Step 4*
4	Inspect the connecting rods. Is there a misaligned connecting rod?		Go to*Pistons and Rods Replacement Procedure*	Go to *Step 5*
5	Inspect the piston position. Is the piston 180˚ out of position?		Go to*Pistons and Rods Replacement Procedure*	System OK

Valve Mechanism or Valve Train Noises

Step	Action	Value(s)	Yes	No
1	Is a light tapping sound heard from the engine?		Go to *Step 2*	System OK
2	Inspect the valve springs. Are the springs weak or broken?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	Go to *Step 3*
3	Inspect the valves. Are the valves sticking or warped?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	Go to *Step 4*
4	Inspect the valve lifters. Are the valve lifters dirty, stuck or worn?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	Go to *Step 5*
5	Inspect the camshaft lobes. Are the camshaft lobes damaged or improperly machined?		Go to*Camshaft Replacement Procedure*	Go to *Step 6*
6	Check the oil supply to the valve train. Is the oil supply insufficient or poor?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	Go to *Step 7*
7	Inspect the valve guides. Are the valve guides worn?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	Go to *Step 8*
8	Inspect the valve spring seat. Is the valve spring seat incorrect?		Go to*Cylinder Head and Valve Train Components Replacement Procedure*	System OK

GENERAL INFORMATION

CLEANLINESS AND CARE

An automobile engine is a combination of many machined, honed, polished and lapped surfaces with tolerances that are measured in the ten–thousandths of an inch. When any internal engine parts are serviced, care and cleanliness are important. A liberal coating of engine oil should be applied to friction areas during assembly, to protect and lubricate the surfaces on initial operation. Proper cleaning and protection of machined surfaces and friction areas is part of the repair procedure. This is considered standard shop practice, even if not specifically stated.

Whenever valve train components are removed for service, they should be kept in order. They should be installed in the same locations, and with the same mating surfaces, as when they were removed.

Battery cables should be disconnected before any major work is performed on the engine. Failure to disconnect the cables may result in damage to wire harness or other electrical parts.

ON–ENGINE SERVICE

CAUTION : Disconnect the negative battery cable before removing or installing any electrical unit, or when a tool or equipment could easily come in contact with exposed electrical terminals. Disconnecting this cable will help prevent personal injury and damage to the vehicle. The ignition must also be in LOCK unless otherwise noted.

Notice : Any time the air cleaner is removed, the intake opening should be covered. This will protect against the accidental entrance of foreign material, which could follow the intake passage into the cylinder, and cause extensive damage when the engine is started.