GROUP

ENGINE 03

(6000 & 9000)

SECTION 03-00 Engine—Service

VEHICLE APPLICATION

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DESCRIPTION

This Section covers various engine tests and cleaning and inspection procedures.

For engine removal, disassembly, cleaning and inspection, assembly, installation, adjustment procedures and specifications, refer to Section 03-01.

These engines incorporate a closed-type crankcase ventilation system and exhaust emission control system. All engine / emission control systems are covered in Powertrain Control / Emissions Diagnosis Manual[1].

To maintain the required exhaust emission levels, the fuel system, ignition system and engine must be kept in good operating condition and meet recommended adjustment specifications.

When performing tests, adjustment or service to the engine or fuel / ignition system, it is essential to follow the procedures and specifications in the appropriate group in this manual.

Before replacing damaged or worn engine components such as the crankshaft, cylinder heads, valve guides, valves, camshafts or cylinder block, make sure that part(s) is not serviceable.

WARNING: TO AVOID THE POSSIBILITY OF PERSONAL INJURY OR DAMAGE TO THE VEHICLE, DO NOT OPERATE THE ENGINE WITH THE HOOD OPEN UNTIL THE FAN HAS FIRST BEEN EXAMINED FOR POSSIBLE CRACKS AND SEPARATION.

1 Can be purchased as a separate item.

DESCRIPTION (Continued)

Exhaust Emission Control System

Operation, removal, installation and required maintenance of the exhaust emission control devices used on these engines are covered in Powertrain Control / Emissions Diagnosis Manual.[2]

Engine Identification

For quick engine identification, refer to the Safety Certification Decal. The decal is mounted on the LH front door lock face panel. Find the engine code (letter or number) on the decal, then refer to the engine identification chart to determine the engine type and size. An engine identification label is also attached to the engine. The symbol code on the identification tag identifies each engine for determining parts usage; for instance, engine displacement and model year. Engine decal information is located in the appropriate engine section.

Emission Calibration Label

The emission calibration number label is located on the LH side door or LH door post pillar. It identifies the engine calibration number, the engine code number and revision level.

These numbers are used to determine if parts are unique to specific engines.

Always refer to these labels when replacement parts are required or when checking engine calibrations. Engine parts often differ within a CID family. Verification of identification codes will ensure that the proper parts are obtained. The codes contain all pertinent information relating to dates, optional equipment and revisions. The Ford Master Parts Catalog contains a complete listing of the codes and their application.

DIAGNOSIS AND TESTING

Closed-Type Positive Crankcase Ventilation (PCV) System

A malfunctioning closed (PCV) system may be indicated by loping or rough engine idle. Do not attempt to compensate for this idle condition by disconnecting the crankcase ventilation system and making an air by-pass or idle speed adjustment.

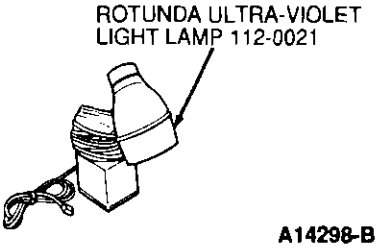
CAUTION: The removal of the PCV system from the engine will adversely affect the fuel economy and engine ventilation with resultant shortening of engine life.

To determine whether the loping or rough idle condition is caused by a malfunctioning PCV system, refer to Powertrain Control / Emissions Diagnosis Manual.[1]

Engine Oil Leaks

When diagnosing engine oil leaks, it is important that the source and location of the leak be positively identified prior to service. The following procedure has been found to be very effective and requires only a minimum of equipment. Prior to using this procedure, it is important to clean the cylinder block, cylinder head, cylinder head cover, oil pan and flywheel housing areas with a suitable solvent to remove all traces of oil.

Use the following procedure to perform oil leak diagnosis with Ultraviolet Light Lamp 112-00021 or equivalent.



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Fluorescent Oil Additive Method

1. Clean engine with a suitable solvent to remove all traces of oil.
2. Drain engine oil crankcase and refill with recommended oil, premixed with Fluorescent Oil Additive ESE-M99C103-A or equivalent. Use a minimum 14.8ml (1/2 fluid oz) to a maximum 29.6ml (1 fluid oz) of fluorescent additive to all engines. If oil is not premixed, fluorescent additive must be added to crankcase first.
3. Run engine for 15 minutes. Stop engine and inspect all seal and gasket areas for leaks using Ultraviolet Light Lamp 112-00021 or equivalent. A clear bright yellow or orange area will identify leak.
4. If necessary, pressurize main oil gallery system to locate leaks due to improperly sealed, loose or cocked plugs. If flywheel bolts leak oil, look for sealer on threads.
5. Service all leaks as required.

Pressure Method

Alternative Testing Procedure

The main oil gallery can be pressurized to locate oil leaks. The following materials are required to fabricate the tool to be used.

- Air supply and air hose.
- Air pressure gauge that registers pressure in one psi increments.
- Air line shutoff valve.
- Appropriate fittings to attach above parts to oil fill and PCV tube connections.
- Appropriate plugs to seal any openings leading to crankcase.

2 Can be purchased as a separate item.

DIAGNOSIS AND TESTING (Continued)

- A solution of liquid detergent and water to be applied with a suitable-type applicator such as a squirt bottle or brush.

Fabricate the air supply hose to include the air line shutoff valve and the appropriate adapter to permit the air to enter the engine through the cylinder head cover tube. Fabricate the air pressure gauge to a suitable adapter for installation on the engine at the oil fill opening.

Testing Procedure

1. Open air supply valve until pressure gauge maintains 34 kPa (5 psi).
2. Inspect sealed and / or gasketed areas for leaks by applying "Snoop" Pressure Check or a solution of liquid detergent and water over areas for formation of bubbles, which indicates leakage.

Possible Leakage Points

Examine the following areas for oil leakage.

Under Hood

- Cylinder head cover gasket
- Intake manifold gasket
- Cylinder head gasket
- Oil filter
- Distributor O-ring
- Oil level indicator (dipstick) tube connection
- Oil pressure sending unit
- Cup plugs and / or pipe plugs at end of oil passages

Under Engine--With Vehicle on Hoist

- Oil pan gasket
- Oil pan front and rear end seals
- Crankshaft front seal
- Crankshaft rear seal

With Transaxle and Flywheel Removed

- Crankshaft rear seal
- Rear main bearing cap parting line
- Rear main bearing cap and seals
- Flywheel mounting bolt holes
- Rear cup plugs and or pipe plugs at the end of oil passages

Air leakage in area around a crankshaft rear oil seal does not necessarily indicate a rear seal leak. However, if no other cause can be found for oil leakage, it can be assumed that rear seal is the cause of the oil leakage.

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

NOTE: Light foaming equally around cylinder head cover bolts and crankshaft seals is normal and no corrections are required in such cases.

Excessive Engine Oil Consumption

The amount of oil an engine uses will vary with the way the vehicle is driven in addition to normal engine-to-engine variation. This is especially true during the first 12,000 km (7,500 miles), when a new engine is being broken in or until certain internal engine components become conditioned. Vehicles used in heavy-duty operation (severe service) may use more oil. The following are examples of heavy-duty operation:

- Trailer towing applications
- Severe loading applications
- Sustained high speed operation

Engines need oil to lubricate the following internal components:

- Engine block cylinder walls
- Pistons and piston rings
- Intake and exhaust valve stems
- Intake and exhaust valve guides
- All internal engine components

When the pistons move downward, a thin film of oil is left on the cylinder walls. The thin film of oil is burned away on the firing stroke during combustion. If an engine burned a drop of oil during each firing stroke, oil consumption would be about one (1) quart for every mile traveled. Fortunately, modern engines use much less oil than this example. However, even efficient engines will use some oil or they would quickly wear out. Additionally, as the vehicle is operated, some oil is drawn into the combustion chambers past the intake and exhaust valve stem seals and burned.

Many different conditions can affect oil consumption rates. The following is a partial list of these items:

- Engine size
- Operator driving habits
- Ambient temperature
- Quality and viscosity of the oil

Operation under varying conditions can be frequently misleading. A vehicle that has been run for several thousand miles of short trip operation or below freezing ambient temperatures, may have consumed a "normal" amount of oil. However, when checking the engine oil level, it may measure up to the full mark on the dipstick due to dilution (condensation and fuel) in the engine crankcase. The vehicle then might be driven at high speeds on the highway where the condensation and fuel boil off. The next time the engine oil is checked, it may appear that a quart of oil was used in a hundred or so miles. This perceived 160 km (100 miles) per quart oil consumption rate causes customer concern even though the actual overall oil consumption rate was about 2,400 km (1,500 miles) per quart.

DIAGNOSIS AND TESTING (Continued)

Make sure the selected engine oil meets the recommended API performance category "SG" and SAE viscosity grade as shown in the vehicle Owner Guide. It is also important that the engine oil is changed at the intervals specified for the typical operating conditions. Refer to Section 00-03, Maintenance and Lubrication.

The following diagnostic procedure is intended to be used to determine the source of excessive internal oil consumption.

1. Determine what is considered excessive oil consumption, i.e., how many miles are driven per quart of oil? Also, determine owner's driving habits, i.e., sustained high speed operation, towing, extended idle, etc.

Oil usage is normally greater during the first 7,500 miles of service. As mileage increases, oil usage generally decreases. Vehicles in normal service should get at least 900 miles per quart after 7,500 miles of service. Vehicles that are subjected to severe duty (high speed driving, towing, high ambient temperature, etc.) may result in greater oil usage.

NOTE: Vehicles over 8500 GVWR will consume more oil

2. Verify engine has no external oil leak as outlined under Engine Oil Leaks.
3. Verify engine has correct engine oil indicator dipstick.
4. Verify that the engine is NOT being run in an overfilled condition. Check the oil level at least 5 minutes after a hot shutdown with the vehicle parked on a level surface. In no case should the level be above the top of the cross-hatch area and "F" in FULL. If a significant overfill is indicated, perform Steps 5 through 5d.
5. Perform an oil consumption test:
   a. Drain engine oil, remove filter and refill with one quart less than the recommended oil.
   b. Run the engine for three minutes (ten minutes if cold), then allow oil to drain for at least 5 minutes with vehicle on level surface.
   c. Remove engine oil dipstick and wipe clean (do not wipe with anything contaminated with silicone compounds). Re-install dipstick being sure to seat the dipstick firmly in the tube. Remove the dipstick and scribe a mark on the back (unmarked) surface at the indicated oil level. (This level should be about the same as the ADD mark on the face of the dipstick).
   d. Add one US Quart of oil, restart the engine and allow to idle for at least two minutes. Shut off the engine and allow oil to drain back for at least 5 minutes. Mark the dipstick using the procedure above. (This level may range from slightly below the top of the cross-hatched area to slightly below the letter "F" in FULL.)
   e. Record vehicle's mileage.
   f. Instruct the owner to drive the vehicle as usual and:
      - Check the oil level regularly at intervals of 100 to 150 miles.
      - Return to the service point when the oil level drops below the lower (ADD) mark on the dipstick.
      - In an emergency, add only full quarts of the same oil and note the mileage at which the oil is added.
   g. Check the oil level under the same conditions and at the same location as in Steps c and d above.
      - Measure the distance from the oil level to the upper scribe mark on the dipstick and record.
      - Measure the distance between the two scribe marks and record.
      - Divide the fist measurement by the second.
      - Divide the distance driven during the oil test by the result. This quantity is the approximate oil consumption rate in miles per quart (MPQ).
   h. If the oil consumption rate determined is unacceptable, proceed to Step 6.
6. Check PCV valve system. Make sure system is not plugged.
7. Check for plugged oil drain-back holes in cylinder head(s), and cylinder block.
8. If after performing the above, the condition still exists, proceed to Step 9.
9. Perform a cylinder compression test as outlined, and/or perform a cylinder leak detection test with Tester 014-00705. This can be helpful in determining source of oil consumption, i.e., valves, piston rings, etc.
10. Check valve guides for excessive guide clearance. Replace all valve stem/guide seals after correct valve guide clearance has been verified.
11. Worn or damaged internal engine components can cause excessive oil consumption. Small deposits of oil on tip of spark plugs can be a clue to internal oil consumption. If internal oil consumption still persists, proceed as follows:
    a. Remove engine from vehicle and place it on an engine work stand. Remove intake manifold(s), cylinder head(s), oil pan and oil pump. Refer to procedure in the appropriate engine section of the Car/Truck Service Manual.
    b. Check piston ring clearance, ring gap and ring orientation. Service as required.

DIAGNOSIS AND TESTING (Continued)

c. Check for excessive bearing clearance. Service as required.

NOTE: After checking for worn parts, if it is determined parts should be replaced, make sure correct replacement parts are used.

12. Perform oil consumption test to confirm oil consumption concern has been resolved.

Compression Test

Compression Gauge Check

1. Ensure oil in crankcase is of the correct viscosity and at proper level and battery is properly charged. Operate vehicle until engine is at normal operating temperature. Turn off ignition switch, then remove all spark plugs.
2. Set throttle plate to wide-open position.
3. Install a compression gauge such as Rotunda Compression Tester 059-00009 or equivalent in No. 1 cylinder.
4. Install an auxiliary starter switch in starting circuit. With ignition switch in the OFF position, and using auxiliary starter switch, crank engine at least five compression strokes and record highest reading. Note the approximate number of compression strokes required to obtain the highest reading.
5. Repeat test on each cylinder, cranking the engine approximately the same number of compression strokes.

Test Conclusion

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

Compression Pressure Limit Chart

Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI	Maximum PSI	Minimum PSI
134	101	164	123	194	145	224	168
136	102	166	124	196	147	226	169
138	104	168	126	198	148	228	171
140	105	170	127	200	150	230	172
142	107	172	129	202	151	232	174
144	108	174	131	204	153	234	175
146	110	176	132	206	154	238	177
148	111	178	133	208	156	238	178
150	113	180	135	210	157	240	180
152	114	182	136	212	158	242	181
154	115	184	138	214	160	244	183
156	117	186	140	216	162	246	184
158	118	188	141	218	163	248	188
160	120	190	142	220	165	250	187
162	121	192	144	222	166		

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If one or more cylinders read low, squirt approximately one tablespoon of heavy SAE 50 weight or equivalent engine oil on top of the pistons in the low reading cylinders. Repeat compression pressure check on these cylinders.

1. If compression improves considerably, piston rings are at fault.
2. If compression does not improve, valves are sticking or seating improperly.

DIAGNOSIS AND TESTING (Continued)

3. If two adjacent cylinders indicate low compression pressures and squirting oil on pistons does not increase compression, the cause may be a cylinder head gasket leak between cylinders. Engine oil and / or coolant in cylinders could result from this situation.

   It is recommended the Compression Pressure Limit Chart be used when checking cylinder compression so that the lowest reading number is 75 percent of the highest reading.

Example

If, after checking the compression pressures in all cylinders, it was found that the highest reading obtained was 196 psi and the lowest pressure reading was 155 psi, the engine is within specification and the compression is considered satisfactory.

Static Engine Off Valve Train Analysis

Cylinder Head Cover Removed

NOTE: Refer to Section 03-01 for the Removal and Installation of the engine cylinder head cover.

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

Check for damaged and / or severely worn parts, for correct assembly, and ensure use of correct parts by proceeding as follows, with the static engine analysis.

Cylinder Head

- Check the cylinder head gasket for proper installation.
- Check for plugged oil drain back holes.
- Check valve lash. Refer to Section 03-01.

Dynamic Valve Train Analysis

Start the engine and, while running at idle, check for proper operation of all parts. Check the following:

Cylinder Head

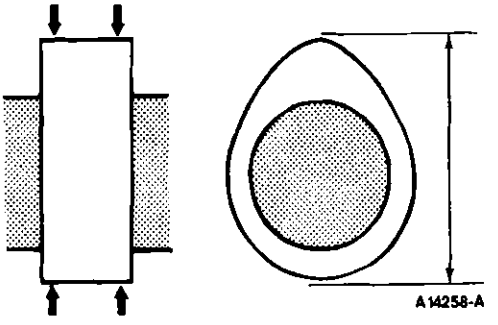
- Plugged oil drain back holes.

Camshaft Lobe Lift

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

1. Remove cylinder head cover.
2. Install Dial Indicator with Bracketry TOOL-4201-C or equivalent in such a manner as to have dial indicator tip on the camshaft lobe being checked.
3. Remove spark plugs.
4. Connect an auxiliary starter switch in starting circuit. Crank engine with ignition switch in OFF position. "Bump" engine over until dial indicator tip is on base circle of camshaft lobe. At this point, dial indicator will be in its lowest position. If checking during engine assembly, turn crankshaft using a socket or rachet.
5. Zero dial indicator. Continue to rotate crankshaft slowly until camshaft lobe is at full lift position (highest indicator reading).

   NOTE: Camshaft lobe lift must be checked at two points as illustrated.



6. Compare total lift recorded on indicator with specifications. Refer to Section 03-01.
7. To check accuracy of original indicator reading, continue to rotate crankshaft until indicator reads zero.

   NOTE: If lift on any lobe is below specified service limits, camshaft must be replaced.
8. Remove dial indicator and auxiliary starter switch.
9. Install cylinder head cover.
10. Install spark plugs.

SPECIAL SERVICE TOOLS

Tool Number	Description
TOOL-4201-C	Dial Indicator with Bracketry

ROTUNDA EQUIPMENT

Model	Description
112-00021	Ultraviolet Light Lamp
059-00009	Compression Tester