Engine Cooling

Special Tool(s)

 ST1474-A	Radiator Pressure Tester 014-R1072 or equivalent
 ST2332-A	Worldwide Diagnostic System (WDS) 418-F224 New Generation STAR Tester (NGS) 418-F052 (007-00520) or equivalent
 ST1477-A	Power Steering Analyzer 014-00207 (D79L-33610-A)
 ST1396-A	Dial Thermometer 0-220°F 023-R0007
	Battery/Antifreeze Tester 014-R1060 or equivalent

 ST1720-A	

Inspection and Verification

WARNING: To avoid personal injury, do not unscrew the coolant pressure relief cap while the engine is operating or hot. The cooling system is under pressure; steam and hot liquid can come out forcefully when the cap is loosened slightly.

CAUTION: Check the coolant level, engine oil and transmission fluid, top off the coolant if needed. If there is engine coolant in the engine oil or transmission fluid, the cause must be corrected and oil/fluid changed or major component damage may occur.

CAUTION: Some vehicle cooling systems are filled with Motorcraft Premium Engine Coolant VC-4-A (in Oregon VC-5, in Canada CXC-10 or equivalent) meeting Ford specification ESE-M97B44-A (green color). Others are filled with Motorcraft Premium Gold Engine Coolant VC-7-A meeting Ford specification WSS-M97B51-A1 (yellow color). Do not mix coolant types.

1. Verify the customer concern by operating the engine to duplicate the condition.
2. Inspect to determine if any of the following mechanical or electrical concerns apply.

Visual Inspection Chart

Mechanical	Electrical
• Leaks • Restricted airflow through the condenser/radiator • Damaged hoses • Loose/damaged hose clamps • Damaged water gasket • Damaged head gaskets	• Damaged cylinder head temperature sensor • Damaged wiring • Hydraulic cooling fan pump solenoid/solenoid wiring

• Damaged water pump
• Damaged radiator
• Damaged degas bottle
• Damaged heater core
• Hydraulic cooling fan system
  ▪ Fluid level
  ▪ Hydraulic line or joint leaks
  ▪ Kinked hydraulic lines	

CAUTION: The cylinder head temperature sensor is not reusable after removal on 3.9L engines. For electrical concern testing refer to the Powertrain Control/Emissions Diagnosis (PC/ED) manual.

3. If the inspection reveals an obvious concern that can be readily identified, repair it as necessary.

4. Inspect the coolant condition:

Inspect the coolant color.

- If Motorcraft Premium Engine Coolant (green-color) VC-4-A or equivalent meeting Ford specification ESE-M97B44-A has a clear, light green or blue color, this indicates higher water content than required.
- If Motorcraft Premium Gold Engine Coolant (yellow-color) VC-7-A or equivalent meeting Ford specification WSS-M97B51-A1 has a clear or pale yellow color, this indicates higher water content than required.
- Dark brown could indicate unauthorized stop leak may have been used. Use Motorcraft System Stop Leak Powder, part number E6AZ-19558-A (and RA-2) or equivalent meeting Ford specification ESE-M99B170-A except as noted in ES-F6SE-19A511-AA.
- A light or reddish brown color indicates that rust may be present in the cooling system. Flush the system and refill with the correct mixture of water and Premium Engine Coolant or Premium Engine Gold Coolant.
- An iridescent sheen on the surface of the coolant could indicate a trace of oil is entering the system. For additional information on engine diagnosis, refer to Section 303-00 .
- A milky brown color may indicate that either engine oil or transmission fluid is entering the cooling system. If transmission fluid is suspected, the cause may be a leaky radiator. Pressure test the cooling system. Refer to component tests in this section.
- If engine oil is suspected, the cause of the leak may be internal to the engine. For additional information on engine diagnosis, refer to Section 303-00 .
- If transmission fluid is contaminated with engine coolant, the cause may be a leaky radiator, pressure test the system. Refer to component tests in this section.

If the engine coolant appearance is acceptable, test the engine coolant freezing point range with the Battery/Antifreeze tester. The freezing point should be in the range -50°F to -10°F. If the vehicle is driven in cold climates less than -34°F, it may be necessary to increase the coolant concentration to get adequate freeze protection.

Maximum coolant concentration is 60/40.

Minimum coolant concentration is 40/60.

Adjust coolant range and level if necessary:

- If the coolant is low, add specified coolant mixture only.
- If the coolant tests weak, add straight engine coolant until the readings are within acceptable levels.
- If the coolant tests strong, remove some of the engine coolant and add water until the readings are within acceptable levels.

5. If the concern remains after the inspection, determine the symptom(s). GO to Symptom Chart .

6. Verify the cooling system is correctly filled and bled. Refer to Cooling System Draining, Filling And Bleeding in this section.

Symptom Chart

Symptom Chart

Condition	Possible Sources	Action
• Loss of engine coolant	• Radiator. • Thermostat housing assembly. • Auxiliary water pump. • Heater control valve. • Oil cooler. • PCV heater system. • Throttle body adapter heating. • Water pump seal. • Radiator hoses. • Heater hoses.	• Go To Pinpoint Test A .

	• Heater core. • Engine gaskets. • Degas bottle.	
• The engine overheats	• Water thermostat. • Airlock in the system. • Water pump. • Internal engine coolant leak. • Radiator. • Radiator airflow obstruction. • Heater core. • Cooling fan. • Pressure relief cap.	• Go To Pinpoint Test B .
• The engine does not reach normal operating temperature	• Water thermostat.	• Go To Pinpoint Test C .
• The block heater does not operate correctly	• Block heater power cable. • Block heater.	• DISCONNECT the power cable from the heater. • CHECK the resistance in all three power cable circuits. If the resistance is greater than 5 ohms in any circuit, INSTALL a new power cable. If the resistance is less than 5 ohms in all three circuits, INSTALL a new block heater.
• Noisy cooling fan operation	• Incorrect fluid level. • Kinked or leaking line. • Blocked reservoir screen. • Hydraulic motor. • Hydraulic pump.	• REFILL fluid to specified level. REFER to Hydraulic Cooling Fan System Filling and Bleeding . CHECK for leaks and retest. • INSTALL a new line. RETEST and CHECK for leaks. • REFER to Component Tests in this section.

Pinpoint Tests

PINPOINT TEST A: LOSS OF COOLANT

CONDITIONS	DETAILS/RESULTS/ACTIONS
A1 CHECK THE ENGINE COOLANT LEVEL	
NOTE: Allow the engine to cool before checking the engine coolant level.	
1 	2 **WARNING: To avoid personal injury, do not unscrew the coolant pressure relief cap while the engine is operating or hot. The cooling system is under pressure; steam and hot liquid can come out forcefully when the cap is loosened slightly.** Visually check the engine coolant level at the degas bottle. • **Is the engine coolant level within specification?** → **Yes** GO to A2 . → **No** REFILL the engine coolant as necessary. GO to A6 .
A2 DEGAS BOTTLE PRESSURE RELIEF CAP	
	1 **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions can result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).** Allow the engine to cool. 2 Remove the pressure relief cap. 3 Inspect the pressure relief cap for foreign material between the sealing gasket and the diaphragm.

	• **Is the pressure relief cap OK?** → **Yes** REFER to Component Tests. → **No** CLEAN or INSTALL a new pressure relief cap. TEST the system for normal operation. GO to A1 .
A3 CHECK THE ENGINE COOLANT FOR INTERNAL LEAK	
WARNING: To avoid personal injury, do not unscrew the coolant pressure relief cap while the engine is operating or hot. The cooling system is under pressure; steam and hot liquid can come out forcefully when the cap is loosened slightly.	
1 	2 Inspect the engine coolant in the degas bottle for signs of engine oil. • **Is oil evident in the coolant?** → **Yes** If engine oil is evident, REFER to Section 303-00 . → **No** GO to A4 .
A4 CHECK THE ENGINE FOR COOLANT	
	1 Remove the oil level indicator from the engine. • **Is coolant evident in the oil?** → **Yes** If coolant is in the engine, REFER to Section 303-00 .

	→ **No** GO to A5 .
A5 PRESSURE TEST THE ENGINE COOLING SYSTEM	
	1 Pressure test the engine cooling system. Refer to the Component Tests in this section. • **Does the engine cooling system leak?** → **Yes** REPAIR or INSTALL new components. TEST the system for normal operation. → **No** The cooling system is operational. GO to Symptom Chart .
A6 CHECK THE DEGAS BOTTLE	
	1 **WARNING: To avoid personal injury, do not unscrew the coolant pressure relief cap while the engine is operating or hot. The cooling system is under pressure; steam and hot liquid can come out forcefully when the cap is loosened slightly.** **NOTE:** The engine must be cool when coolant is added to the degas bottle. Add coolant to the degas bottle until fluid is between the coolant fill level marks. • **Does the degas bottle leak?** → **Yes** INSTALL a new degas bottle. TEST the system for normal operation. → **No** CARRY OUT the cooling system pressure test. REFER to the Component Tests in this section. REPAIR as necessary. TEST the system for normal operation.

PINPOINT TEST B: THE ENGINE OVERHEATS

CONDITIONS	DETAILS/RESULTS/ACTIONS

B1 CHECK THE ENGINE COOLANT LEVEL	
NOTE: If the engine is hot, allow the engine to cool before proceeding.	
1 	1 **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions can result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).** 2 Check the engine coolant level at the degas bottle. • **Is the engine coolant OK?** → **Yes** GO to B2 . → **No** REFILL the engine coolant at the degas bottle. Go To Pinpoint Test A .
B2 CHECK THE COOLANT CONDITION	
	1 Check the coolant for contaminants such as rust, corrosion, or discoloration. • **Is the coolant condition OK?** → **Yes** GO to B3 . → **No** FLUSH the engine cooling system. REFER to Engine and Radiator Flushing in this section. TEST the system for normal operation.
B3 CHECK FOR AN AIRFLOW OBSTRUCTION	
	1 Inspect the A/C condenser core and radiator for obstructions such as leaves or dirt. • **Is there an obstruction?**

	→ **Yes** REMOVE the obstruction. CLEAN the A/C condenser core and radiator. TEST the system for normal operation. → **No** GO to B4 .
B4 CHECK THE HEATER CORE OPERATION	
2 	1 Install the pressure relief cap. 3 As the engine starts to heat up, feel the inlet and outlet heater water hoses. They should feel approximately the same after three or four minutes. • **Is the outlet heater water hose approximately the same temperature as the inlet heater water hose?** → **Yes** GO to B5 . → **No** TURN the engine off. REPAIR or INSTALL a new heater core. REFER to Section 412-00 . TEST the system for normal operation.
B5 CHECK THE WATER THERMOSTAT OPERATION	
1  2 	1 Start the engine and allow the engine to run for 10 minutes. 3 Feel the upper and lower radiator hoses.

	• **Are the upper and lower radiator hoses cold?** → **Yes** INSTALL a new water thermostat. TEST the system for normal operation. → **No** GO to B6 .
B6 CHECK THE COOLING FAN OPERATION	
1 	1 Carry out the cooling fan component tests. Refer to the Component Tests in this section. • **Is the cooling fan operation OK?** → **Yes** REFER to Section 303-00 for diagnosis and testing of the engine. → **No** INSTALL a new fan component as necessary. TEST the system for normal operation.

PINPOINT TEST C: THE ENGINE DOES NOT REACH NORMAL OPERATING TEMPERATURE

CONDITIONS	DETAILS/RESULTS/ACTIONS
C1 CHECK THE ENGINE TEMPERATURE	
1  2	1 Start the engine and allow the engine to idle for 10 minutes. 2 Feel the upper and lower radiator hoses.

	• **Are the upper and lower radiator hoses cold?** → **Yes** INSTALL a new water thermostat. TEST the system for normal operation. → **No** REFER to Section 413-01 for diagnosis and testing of the engine coolant temperature gauge.

Component Tests

Pressure Test

1. Turn the engine OFF.
2. Remove the cowl vent screen. Refer to Section 501-02 .
3. **WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions can result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, never remove the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove the pressure relief cap (still with a cloth).**

   Check the engine coolant level. Refer to Cooling System Draining, Filling And Bleeding in this section.
4. Connect the Radiator/Heater Core Pressure Tester to the degas bottle nipple and overflow hose. Install a pressure test pump to the quick-connect fitting of the test adapter.
5. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

6. If the pressure relief cap does not hold pressure, remove and wash the pressure relief cap in clean water to dislodge all foreign particles from the gaskets. Check the sealing surface in the filler neck.

7. If 8-9 kPa (13 psi) cannot be reached, install a new pressure relief cap. If more than 12 kPa (18 psi) shows on the gauge, install a new pressure relief cap.

8. **CAUTION: If the pressure drops, check for leaks at the engine to heater core hoses, engine-to-radiator hoses, water valve hose (if applicable), oil cooler return tube gasket, radiator and heater core or other system components and connections. Any leaks which are found must be corrected and the system rechecked.**

   Pressurize the engine cooling system as described in Step 4 (using a pressure relief cap that operates within the specified upper and lower pressure limits). Observe the gauge reading for approximately two minutes; refer to General Specifications. Pressure should not drop during this time.

9. Release the system pressure by loosening the pressure relief cap. Check the engine coolant level and replenish, if necessary, with the correct engine coolant mixture. Refer to Cooling System Draining, Filling And Bleeding in this section.

Cap

WARNING: Never remove the pressure relief cap under any conditions while the engine is operating. Failure to follow these instructions can result in damage to the cooling system or engine and/or personal injury. To avoid having scalding hot coolant or steam blow out of the cooling system, use extreme care when removing the pressure relief cap from a hot degas bottle. Wait until the engine has cooled, then wrap a thick cloth around the pressure relief cap and turn it slowly one turn (counterclockwise). Step back while the pressure is released from the cooling system. When certain all the pressure has been released, remove pressure relief cap (still with a cloth).

1. Remove the pressure relief cap from the degas bottle.

2. Immerse the pressure relief cap in water and install it on the shallow filler neck of Radiator/Heater Core Pressure Tester and Radiator Cap Adapter, part of the Radiator/Heater Core Pressure Tester.

3. Immerse the filler neck seal in water and install it in the filler neck adapter.

4. Install the filler neck adapter with the filler neck seal to the Radiator Cap Adapter.

5. Connect the female quick-connect fitting of the pressure test pump to the male quick-connect fitting of the filler neck adapter.

6. **NOTE:** If the plunger of the pump is depressed too fast, an erroneous pressure reading will result.

   Slowly depress the plunger of the pressure test pump until the pressure gauge reading stops increasing and note the highest pressure reading obtained.

7. Release the pressure by turning the relief screw counterclockwise. Then tighten the pressure relief screw and repeat Step 6 (at least twice) to make sure the reading is repeatable within the specifications of the pressure relief cap.

8. If the pressure test gauge readings are not within specifications, install a new pressure relief cap. If the pressure test gauge readings are within specifications, carry out the cooling system Pressure Test.

Thermostat—Water

A new water thermostat should be installed only after the following electrical and mechanical tests have been carried out.

Thermostat—Electrical Test

NOTE: The electrical thermostat test is most accurate if carried out indoors at less than 37.8°C (100°F) ambient air. This test may be carried out with or without the hood open and with the engine warm or cold.

1. Check the engine coolant level. Fill as needed.

2. With the ignition OFF, attach the Rotunda 73 Digital Multimeter. It may be used to monitor sensor voltage values between 0-5 volts.

3. **NOTE:** Running this test with the vehicle in gear or with the A/C compressor clutch engaged (running) will cause incorrect diagnosis.

   Place the transmission in PARK (P) or NEUTRAL (N).

4. Start the engine and allow the engine to idle throughout this test. Allow the engine to run for two minutes, then record the CHT voltage. Record the CHT voltage every 60 seconds. When the CHT voltage trend changes direction or only changes slightly (0.03 volt or less) from the previous reading, record this as the thermostat opening voltage. Use the voltage and corresponding coolant temperature chart listed below.

Coolant Temp °C (°F)	CHT Min (Volts)	CHT Nom (Volts)	CHT Max (Volts)
0 (32)	4.7714	4.8032	4.8723

25 (77)	4.3428	4.4148	4.4727
50 (122)	3.5354	3.6495	3.7473
80 (176)	2.3049	2.4201	2.5260
110 (230)	1.3021	1.3808	1.4562
140 (284)	0.6960	0.7414	0.7857
170 (338)	0.3784	0.4024	0.4261

5. If the thermostat opening voltage is less than 2.3049 volts and less than 80°C (176°F), install a new water thermostat.
6. If the thermostat opening voltage is greater than 2.3049 volts 82°C (180°F), the water thermostat is good and a new water thermostat should not be installed. GO to Symptom Chart .

Thermostat—Mechanical Test

1. Remove the water thermostat.
2. Check the water thermostat for seating. Hold the water thermostat up to a lighted background. Leakage of light around the thermostat valve at room temperature indicates a new water thermostat should be installed. Some water thermostats have a small leakage notch at one location on the perimeter of the thermostat valve, which is considered normal.
3. Immerse the water thermostat in a boiling antifreeze and water mixture.
4. See the General Specifications chart for water thermostat opening temperatures.

Radiator Leak Test, Removed From the Vehicle

CAUTION: Never leak test an aluminum radiator in the same water that copper/brass radiators are tested in. Flux and caustic cleaners may be present in the cleaning tank and they will damage aluminum radiators.

NOTE: Always install plugs in the oil cooler fittings before leak testing or cleaning any radiator.

NOTE: Clean the radiator before leak testing to avoid contamination of tank.

1. Leak test the radiator in clean water with 138 kPa (20 psi) air pressure.

Hydraulic Cooling Fan Reservoir

1. Reduce the fluid in the reservoir by half.
2. Attach the scan tool to the vehicle.
3. Start the engine and command MAX fan.
4. Maintain 2,500 rpm. Fluid should be observed through the reservoir returning. The internal return also functions as a relief valve; fluid must be observed through the sides of the return. If the fluid is not returning through the sides, the screen is plugged. If no or little return is observed or the fluid is returning through the pressure relief, install a new reservoir.

Hydraulic Cooling Fan Motor

1. Inspect the fan blade and shroud for any foreign materials. Clear the obstruction and continue the test procedure.
2. Rotate the fan to see if any contact between the shroud and blade exists. If contact is observed, install a new fan shroud assembly.
3. Rotate the fan by hand. The fan should rotate freely (no resistance should be felt, the fan will free wheel with minimum effort). If any resistance is present, install a new fan assembly.
4. Attempt to move the fan blade and shaft in and out and side to side. If any movement is detected install a new fan assembly.

Hydraulic Cooling Fan Pump

 **WARNING: Do not touch the flowmeter during the test procedure or severe burns and serious injury may occur.**

1. **CAUTION: Make sure that the connection point will not interfere with any of the engine accessory drive components or drive belts.**

   NOTE: On some vehicles the port may not be easily accessible. The power steering analyzer should then be hooked up at the hydraulic cooling fan motor or at a point in the high pressure line between the motor and the hydraulic cooling fan pump.

   Install the power steering analyzer at the high pressure port of the hydraulic cooling fan pump. Make sure the power steering analyzer gate is fully open.

2. **CAUTION: A noisy fan system must be bled and refilled before proceeding with any of the test procedures. Refer to Hydraulic Cooling Fan System Filling and Bleeding in this section.**

   Check the cooling fan hydraulic fluid level. If necessary, add fluid.
   - Use MERCON® Multi-Purpose (ATF) Transmission Fluid XT-2-QDX meeting Ford specification MERCON® or equivalent.

3. Remove the reservoir screen and place the dial thermometer in the hydraulic cooling fan reservoir.

4. Start the engine and allow the engine to warm up until the fan turns on.

5. Allow fluid temperature to reach 74-80°C (165-175°F).

6. Record the flow rate and pressure readings.

7. **NOTE:** The pressure relief valve will open at 1,050 ± 100 psi (7,240 kPa ± 689.5 kPa). If the pressure is above 1,200 psi (8,275 kPa), a new pump pressure relief valve must be installed.

   Turn the A/C on MAX, and record the flow and pressure readings. The flow and pressure readings should increase.
   - If the flow and pressure readings do not increase, install a new hydraulic cooling fan pump.

8. Partially close the gate valve to achieve 300 psi (2,068.5 kPa). The flow rate should be 1.65 ±.25 gpm.
   - If the flow rate is less than specified, install a new hydraulic cooling fan pump.