



Service Coolant Fill Procedure

1 Introduction

Note: Nothing in this standard supercedes applicable laws and regulations.

Note: In the event of conflict between the English and domestic language, the English language shall take precedence.

1.1 Purpose. To simulate what happens in a service environment, when major coolant circuit components are being replaced.

1.2 Applicability. Applicable to all engine cooling systems.

1.3 Remarks.

- Always drain the entire cooling circuit (draining coolant from the radiator, surge tank, engine, heater core, etc.) when performing this test procedure, to ensure static service fill procedures will result in a fully packed cooling system, before returning the vehicle back to service.
- The intent is for a service technician to complete this service fill procedure with as few thermal cycles as possible.
- Improperly running this test procedure may lead to customer dissatisfaction and/or recalls due to (but not limited to): Coolant gurgle noise complaints and/or low engine coolant level without an external leak.
- Data Sheet A1 in Appendix A **must** be completed each time this test procedure is performed.

1.4 Total Cooling System Capacity. The specified fill volume may be obtained prior to vehicle availability using dry components on a flow bench. This volume should be verified and adjusted if necessary using the first assembly plant builds.

2 References

Note: Only the latest approved standards are applicable unless otherwise specified.

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

None

2.3 Additional References.

- Engine thermostat "start to Open" and "full Open" temperature specifications.
- HOKE (www.HOKE.com).
- Kent-Moore Vac-N-Fill Coolant Refill Tool GE 47716.
- Vehicle Technical Specification (VTS) paragraph 3.2.1.5.4.3.1.

3 Resources

3.1 Facilities. For vehicle level testing, any facility with a flat surface and a vehicle lift. For bench level testing, a flow lab facility with coolant handling and fixturing for heat exchangers, plumbing, and engine block. The ambient temperature shall not be $< (20 \pm 5) ^\circ\text{C}$.

3.1.1 Calibration. The test facilities and equipment shall be in good working order and shall have a valid calibration label.

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3.1.2 Alternatives. Alternative test facilities and equipment may also be used. However, all measuring variables as specified in this standard shall be determined correctly with respect to their physical definition.

3.2 Equipment.

3.2.1 Equipment to measure variables as specified in 4.3.19 and 4.4.11.

3.2.2 500 mL and 100 mL beakers, and a beaker or graduated cylinder capable of 10 mL accuracy.

3.2.3 Clean drain pan.

3.2.4 Stopwatch.

3.2.5 Sight glasses.

3.2.6 External cooling fan(s) for reducing wait time between thermal cycles.

3.2.7 Tachometer or other means of measuring the engine rpm (scan tool).

3.3 Test Vehicle/Test Piece. Test vehicle with the latest production intent propulsion system, cooling system hose/pipe routing, vehicle hardware, and software calibrations. The test vehicle shall be verified to have a fully packed cooling system before performing this service fill procedure. Bench level test piece with the latest production intent propulsion system, cooling system hose/pipe routing, and heat exchanger hardware.

3.4 Test Time.

Calendar time: Approximately 2 days to 5 days depending of system complexity and number of thermal cycles.

Test time: Approximately 8 h to 24 h depending of system complexity and number of thermal cycles.

Coordination time: Approximately 3 h to 4 h.

3.5 Test Required Information. Concentration and type of coolant to be provided by Product Engineering.

3.6 Personnel/Skills. Development Engineer and Service Engineer.

4 Procedure

4.1 Preparation.

4.1.1 Before starting the procedure, check to see if the installed coolant pressure cap has the released pressure rating.

4.1.2 Then, ensure test vehicle has a fully packed coolant system, which contains no air (to ensure that, proceed as follows):

- a. With engine coolant temperature (T) at $(21 \pm 3)^\circ\text{C}$, mark actual coolant level in surge tank (or overflow bottle).
- b. Start engine and manually (or with the use of a Multiple Diagnostic Interface (MDI) unit) hold the engine speed at (2500 ± 250) rpm.
- c. Hold at this engine speed for 10 minutes after engine cooling fan initially turns on (or 105°C coolant temperature for engine driven fans).
- d. Vehicles with electronically controlled coolant valve(s) may use a diagnostic interface tool to command full radiator flow rather than warming up the engine. Vehicles with electric main water pumps may further use a diagnostic interface tool to command water pump speed equivalent to 2500 engine rpm rather than turning on the engine. These steps will shorten or eliminate cool-down time.
- e. Shut off the engine. Use a fan to cool the engine and coolant. When the coolant and engine mass has cooled down to $(21 \pm 3)^\circ\text{C}$, compare actual coolant level in the surge tank (or overflow bottle) with the previous mark on the surge tank. If the coolant level has not changed, continue with the following steps in this procedure.
- f. If the coolant level is lower, then repeat the initial thermal cycle until the fluid level does not change after a thermal cycle.

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g. Prior to performing this test procedure on either an overflow or surge tank system, it is beneficial to research and acquire the following specifications for the make/model/engine Regular Production Option (RPO) combination the test is being performed on:

- Engine thermostat "Start to Open" and "Full Open" temperature specifications.
- Electric cooling fan initial on temperature.

Total cooling system capacity as released by Product Engineering.

4.2 Conditions.

4.2.1 Environmental Conditions. Not applicable.

4.2.2 Test Conditions. Deviations from the requirements of this standard shall have been agreed upon. Such requirements shall be specified on component drawings, test certificates, reports, etc.

4.3 Instructions. For Overflow Bottle Systems.

4.3.1 With the coolant at room temperature (21 ± 3) °C, remove the cooling system pressure cap.

4.3.2 Raise and support the test vehicle. Remove any shielding or baffles that restrict access to the appropriate main cooling system drain provision.

4.3.3 These drain provisions can be any combination of the following (assume a service procedure that required as much coolant as possible was removed from the system, short of an engine replacement):

- Radiator draincock.
- Threaded drain bolt(s) on the engine.
- Removal of the engine thermostat.
- Temperature sensor (mounted at the lowest point in radiator end tank).
- Coolant hoses.
- "HOKE" valve.
- Radiator degassing screw and/or radiator vent valve.

4.3.4 Avoid spillage. Any coolant accidentally spilled shall be collected with an absorbent mat and have the wet mat weight compared to a dry mat. The difference in weight shall be converted into volume and added to the volume recovered in the drain pan. Otherwise, go back to the beginning of the procedure and refill the system.

4.3.5 Drain coolant from the radiator or the appropriate cooling system loop into a clean drain pan.

4.3.6 Drain the engine, remove the block drain plugs if equipped.

4.3.7 Drain the heater core. Use shop air to blow remaining coolant out of the heater core and engine block.

4.3.8 For systems with auxiliary coolant loops (e.g., rear heat), the auxiliary heater core and auxiliary coolant loops must be disconnected (possibly at multiple points) and drained. Use shop air to aide in the removal of coolant.

4.3.9 All coolant drained must be captured into a drain pan for measurement purposes.

4.3.10 Reinstall or tighten any components removed or loosened during the draining procedure.

4.3.11 Measure and record the volume of the coolant mixture drained from the system on Data Sheet A1, Box 1a.

4.3.12 Remove the overflow bottle being careful to not leak any coolant. Drain any remaining coolant inside the overflow bottle. Measure and record the amount on Data Sheet A1, Box 1b. Do not reinstall the overflow bottle.

4.3.13 Record the "Total Released Cooling System Volume" released to the assembly plant on Data Sheet A1.

Total Released Coolant System Volume can be determined by one of the following methods:

- a. Math data.
- b. Data based on System Bench development.
- c. Data published in Global Product Description System (GPDS)/Application Processor Module (APM).

4.3.14 Compare Total Volume Drained out of the Vehicle (Data Sheet A1, Box 2) versus the Total Released Cooling System Volume (on Data Sheet A1). It is recommended that Total Volume drained out of the vehicle be a minimum of 70% of the "Total Released Coolant System Volume." If < 70% of the "Total Released Coolant

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System Volume" has been drained out of the vehicle, additional measures and steps shall be taken, in order to drain off the remaining.

4.3.15 Install a sight glass in the upper radiator hose. The influence of the sight glass on the hose routing and the flow distribution must be minimized. An additional sight glass must be installed in the heater outlet hose. The influence of the sight glass on the hose routing and the flow distribution must be minimized.

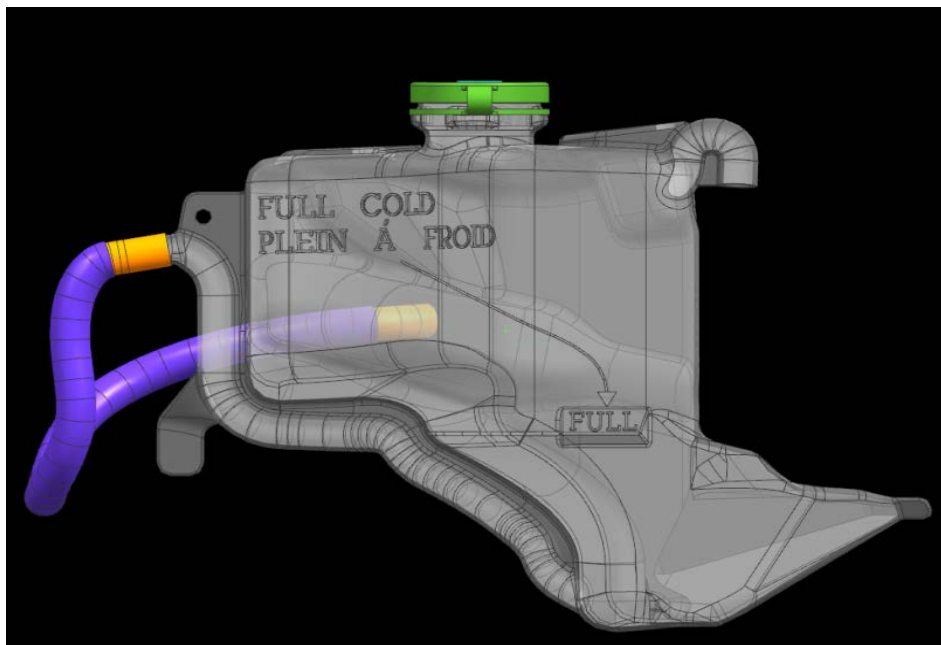
4.3.16 Temperature data must be taken at both the radiator inlet hose and the coolant temperature sensor. If not already instrumented, install thermocouples into the radiator inlet hose and the coolant temp sensor.

4.3.17 Overflow Bottle.

- Position the overflow bottle in a fixture/vise ensuring the overflow bottle is close to vehicle position.
- To calibrate the overflow bottle, either permanently mark or place a piece of markable tape vertically on the overflow bottle relative to the installed vehicle position. The tape is to be visible when the overflow bottle is reinstalled on vehicle. Cap or plug the overflow bottle outlet port to prevent coolant leakage during the tape calibration.
- The FULL marking/symbol on the overflow bottle is to be used and marked as the Zero Reference line. It shall be marked as "Zero Reference" on the markable tape (Figure 1).
- Fill the overflow bottle to the "Zero Reference" line as follows: Pour 100 mL at a time into the bottle and mark each increment on the tape. Record the amount required to fill the overflow bottle to the "Zero Reference" line on Data Sheet A1.
- Continue to fill the overflow bottle above the "Zero Reference" line in 100 mL increments and mark the overflow bottle at each increment (top to bottom).

Drain the overflow bottle completely. Remove the cap from the outlet port and install the overflow bottle back onto the vehicle.

Figure 1: Calibrated Overflow Tank



4.3.18 STEP 1.

- Pinch off the overflow return hose at the radiator to ensure that coolant does not flow into the overflow tank.
- Using a 500 mL beaker, fill the cooling system at the cooling system fill point, while counting each 500 mL increment. It should take no longer than 10 minutes for the coolant level to stabilize at the base of the fill point.

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- c. Record the total amount of coolant added (system and overflow tank), with the engine OFF, on Data Sheet A1, Box 3.

Set the Heating Ventilation Air Conditioning (HVAC) control head to OFF, to allow the coolant system to heat up as fast as possible.

Note: Switchable pump and Cylinder Set Strategy (CSS) engines may require Cabin Heater request to switch on pump and/or open heater circuit. If any valves are present in the system, ensure they are Open. If a radiator degassing screw and/or radiator vent valve is present, keep it Open as long as no coolant spills out.

4.3.19 STEP 2.

- a. Take care to avoid losing any coolant, due to spillage while filling the system or coolant lost due to burping/expulsion out of the system, as this will jeopardize the coolant volume measurement and will cause inconsistency between tests.
- b. Temporarily install the cooling system pressure cap.
- c. Start the engine and a stopwatch. After 30 s remove the cooling system pressure cap and remove the pinch-off pliers from the overflow return hose at the radiator.
- d. While the engine idles with the pressure cap **NOT** installed, monitor the engine coolant temperature sensor reading.

Note: If the coolant temperature does not increase by at least 10 °C within the first 3 minutes of the test, abort and shut off engine (If the engine coolant temperature sensor is not receiving sufficient coolant flow, the electric cooling fans will not turn ON). If this occurs, additional system development needs to occur, to ensure coolant pump priming and sufficient coolant fill, including coverage of the engine coolant temperature sensor. The rate of temperature increase is lower for diesel engines, and can be less than 1 °C per minute above 80 °C operating temperature.

- e. During the Idle with the pressure cap **NOT** installed, record and add coolant as required to maintain the coolant level at the lower base of the coolant fill point trying to minimize the amount of coolant going into the overflow bottle. Continue idling (with the pressure cap **NOT** installed) until coolant begins to expand to the top of the coolant fill point, then install the pressure cap.
- f. On Data Sheet A1, Box 4, record the amount of coolant added during the Idle (when the pressure cap was **NOT** installed).
- g. Record the amount of coolant added up to the "Zero Reference" line on the overflow bottle on Data Sheet A1.
- h. Record on Data Sheet A1 the time when the pressure cap was installed, the radiator inlet thermocouple reading, and the engine coolant temperature sensor reading.
- i. After the initial fill, listen for any gurgle noises audible inside and outside the vehicle, resulting from coolant flow while the engine idles with the pressure cap installed. In vehicle, the HVAC module may act as a speaker to amplify heater core noises. Accordingly, evaluations done on a bench with an exposed heater core may use a stethoscope. Increase engine speed from idle to 3000 rpm while listening. Note observations in the comments section of Data Sheet A1.

4.3.20 STEP 3 (1st Thermal Cycle).

- a. Manually (or with a diagnostic interface tool) hold the engine or main water pump speed at (2500 ± 250) rpm.
- b. Hold at this engine speed for 10 minutes after engine cooling fan initially turns on (or 105 °C coolant temperature for engine driven fans).
- c. Record engine coolant temperature sensor reading and the level of coolant in the overflow bottle on Data Sheet A1, Box 5a.
- d. Inspect the sight glass for a packed system. A packed system is verified by visual inspection of the sight glass in the upper radiator hose.
- e. The visual inspection of the sight glass should be done with the coolant at approximately 105 °C and the engine or main water pump running at a speed between (1500 and 3000) rpm.
- f. The coolant in the sight glass should be dark in color without air bubbles (Figure 2).

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- g. If coolant in the sight glass appears milky in color and/or with air bubbles, then the system is not packed (and additional thermal cycles are required).

If the total coolant volume added is less than was drained (Box 2) then the system is not packed.

- h. Shut off the engine. Use a fan to cool the engine and coolant.
- i. When the coolant has cooled down to $(21 \pm 3)^\circ\text{C}$, record the coolant level in the overflow bottle, relative to the FULL mark, on Data Sheet A1, Box 5b.
- j. If the level of coolant has fallen below the "Zero Reference" line, record the volume of coolant added to the overflow tank, in order to bring the coolant level to the FULL mark, on Data Sheet A1, Box 5c.

Figure 2: De-Aerated versus Aerated Coolant



4.3.21 STEP 4 (Additional Thermal Cycles).

Repeat steps described under STEP 3 until no air is present in the sight glass in the radiator inlet hose when the engine speed is increased to (2500 ± 250) rpm and coolant level in overflow bottle does not change by $> \pm 100$ mL measured at $(21 \pm 3)^\circ\text{C}$. Record numerical values on Data Sheet A1 (Box 6a, 6b, and 6c if required; Box 7a, 7b, and 7c if required; etc.)

The official thermal cycle count is the number of thermal cycles where, after a completed thermal cycle (cold coolant), coolant was needed to be added to bring the system up to the "Zero Reference" line on the overflow bottle.

Note: The last thermal cycle (where no coolant is added to get to the "Zero Reference" line) is not counted, but it must be run (in order to verify the system was packed).

After the system is packed, listen for any gurgle noises audible inside and outside the vehicle, resulting from coolant flow while the engine idles with the pressure cap installed. In vehicle, the HVAC module may act as a speaker to amplify heater core noises. Accordingly, evaluations done on a bench with an exposed heater core may use a stethoscope. Increase engine speed from idle to 3000 rpm while listening. Note observations in the comments section of Data Sheet A1.

Note: After completing the test procedure, it is recommended that the entire procedure be repeated a second time to confirm test repeatability.

4.4 Instructions. For Surge Tank Systems.

Active Thermal Management (ATM) or similar systems using electronically controlled coolant valves and electric main and/or auxiliary coolant pumps may be present on the test vehicle. Identify which type of cooling system control is used and whether an Automatic Coolant Service Fill (ACSF) function is present. ACSF aids service fill by sweeping through a sequence of valve positions and pump speeds, for examples see Appendix C, Table C1 through Table C2. ACSF may be commanded with a diagnostic interface tool, or by meeting a series of entry criteria specified in service information and Appendix B. This procedure shall be executed with ACSF when present.

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Flow bench service fill evaluations of ACSF systems may require manual control of valve(s) and pump(s). See Appendix C for a sample sequence. Bench development of valve positions, pump speeds, and run times is also recommended to optimize the ACSF function.

4.4.1 With the coolant at room temperature (21 ± 3) °C, remove the surge tank cap.

4.4.2 Raise and support the test vehicle.

- a. Remove any shielding or baffles that restrict access to the appropriate main cooling system drain provision. These drain provisions can be any combination of the following (assume a service procedure that required as much coolant as possible was removed from the system, short of an engine replacement):
 - Radiator draincock.
 - Threaded drain bolt(s) on the engine.
 - Removal of the engine thermostat or coolant control valve(s).
 - Temperature sensor (mounted at the lowest point in radiator end tank).
 - Coolant hoses.
 - "HOKE" valve.
 - Radiator degassing screw and/or radiator vent valve.
- b. Avoid spillage, any coolant accidentally spilled shall be collected with an absorbent mat and have the wet mat weight compared to a dry mat. The difference in weight shall be converted into volume and added to the volume recovered in the drain pan. Otherwise, go back to STEP 4 (the beginning of the procedure) and refill the system.

4.4.3 Drain Coolant from the Radiator or the Appropriate Cooling System Loop into a Clean Drain Pan.

- a. Drain the engine, remove the block drain plugs if equipped.
- b. Drain the heater core. Use shop air to blow remaining coolant out of the heater core and engine block.
- c. For systems with auxiliary coolant loops (e.g., rear heat), the auxiliary heater core and auxiliary coolant loops must be disconnected (possibly at multiple points) and drained. Use shop air to aide in the removal of coolant.
- d. All coolant drained must be captured into a drain pan for measurement purposes.
- e. Reinstall or tighten any components removed or loosened during the draining procedure.
- f. Measure and record the volume of the coolant mixture drained from the system on Data Sheet A1, Box 1a.

4.4.4 Remove the surge tank being careful to not leak any coolant. Drain any remaining coolant inside the surge tank. Measure and record the amount on Data Sheet A1, Box 1b. Do not reinstall the surge tank.

4.4.5 Record the "Total Released Cooling System Volume" released to the assembly plant on Data Sheet A1. Total Released Coolant System Volume can be determined by one of the following methods:

- a. Math data.
- b. Data based on System Bench development.
- c. Data published in GPDS/APM.

4.4.6 Compare Total Volume Drained out of the Vehicle (Data Sheet A1, Box 2) versus the Total Released Cooling System Volume (on Data Sheet A1). It is recommended that Total Volume Drained out of the Vehicle be a minimum of 70% of the "Total Released Coolant System Volume." If < 70% of the "Total Released Coolant System Volume" has been drained out of the vehicle, additional measures and steps shall be taken, in order to drain off the remaining.

4.4.7 Install a sight glass in the upper radiator hose. The influence of the sight glass on the hose routing and the flow distribution must be minimized.

Additional sight glasses must be installed in the heater outlet hose and in the degassing hose(s) into the surge tank. Systems which use active coolant flow to additional circuits such as engine and transmission oil warming/cooling should carry sight glasses in these circuits where practical to ensure complete degassing. The influence of the sight glass on the hose routing and the flow distribution must be minimized.

4.4.8 Temperature data must be taken at both the radiator inlet hose and the coolant temperature sensor. If not already instrumented, install thermocouples into the radiator inlet hose and the coolant temp sensor.

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