



Coolant System Bench Evaluation

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 determine if the total coolant flow, flow to the radiator, flow to the heater, flow balance in V-engines, and flow in any other branch of a cooling circuit, meets the design intent under various thermostat opening conditions. To provide hydraulic restriction (pressure drop vs. flow characteristics) data for cooling system modeling and to provide model validation. To ensure surge tank function under dynamic conditions, such as maximum engine speed. To determine the necessity for a 2nd degassing line.

1.2 Applicability. All liquid cooled engines.

1.3 Remarks. This is a bench coolant flow test procedure used for coolant system development.

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. None.

3 Resources

3.1 Facilities. A component test lab or "flow bench" is normally used to complete this test.

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

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 Basic Machine. A speed controlled electric motor with capacity to drive the water pump to approximately 1000 rpm over the equivalent peak engine speed. (Recommend 10 kW at 10 000 rpm, however, some North American applications may require as much as 12 kW at 10 000 rpm.)

3.2.2 Fixturing. T-slot table to hold an engine block, heads, water pump, radiator, heater core, hoses, any additional cooling circuit components and flow meters.

3.2.3 Instrumentation.

3.2.3.1 Magnetic flow meters, sized for appropriate flow rate with minimum pressure drop. Flow rates in various branches of the cooling circuit can range from 150 lpm down to 10 lpm.

3.2.3.2 Torque transducer with speed (rpm) output. Depending on pump size, the torque can range from lower than 1.0 Nm to 10 Nm.

3.2.3.3 Thermocouples and pressure transducers. Expected temperatures are in the range from 15 °C to 120 °C. Expected pressures range from -60 kPa to +850 kPa (for large V-8s) with respect to atmosphere.

3.2.3.4 Glass coolant sight tubes.

3.2.3.5 Data acquisition system.

3.2.4 Coolant Heater. An electric coolant heater is required to raise the coolant temperature to 95 °C for testing. If an external heating circuit is used, this circuit must have valves to isolate the heater during test operation.

3.3 Test Vehicle/Test Piece. A representative block, cylinder head, water pump, thermostat housing, and any additional cooling circuit components from the engine are required. Production-intent cooling components such as radiator, heater core, surge tank/coolant recovery bottle, hoses, and any additional components to complete the cooling circuit are required. If any of the system components are electrically powered, then an appropriate power supply is needed. If any components are actively controlled then means for providing a control signal, e.g., a signal generator, is required.

3.4 Test Time.

Calendar time: 15 d

Test time: 15 h

Coordination time: 25 h

3.5 Test Required Information.

- List of engine and coolant system part numbers.
- Coolant system layout.
- Power supply and control signal specifications.

3.6 Personnel/Skills. Technician must be skilled in test set up, instrumentation and test operation.

4 Procedure

4.1 Preparation.

4.1.1 Install taps in the water pump or fixture for inlet and outlet pressure. In the case of a pump with a double volute, the pressure should be measured in each outlet.

4.1.2 Install pressure taps in the radiator inlet and outlet and the heater inlet and outlet.

4.1.3 Install a pressure tap in the pressurized recovery bottle or near the pressure relief cap in an unpressurized recovery system. This provides a measurement of system reference pressure.

4.1.4 Install pressure taps in the following engine locations (if applicable). Note that in some cases, there will be two (2) measurement locations separated only by a length of hose. This is deliberate and necessary to account for the pressure loss due to each component, including hoses.

- Engine outlet or outlets, if different for radiator, bypass, heater, or oil cooler circuits.
- Crossover outlet or outlets.
- Thermostat assembly locations, both in and out, can vary depending on the type of thermostat and complexity of the thermostat assembly. The intention is to characterize the pressure drop and flows in the thermostat housing and mixing area.
- Heater return port.
- Other locations depending on complexity of the system and requestor's requirements. For example, additional locations on the block and head may be needed to characterize the pressure drop through the block, head gasket, and head. A list of possible measurement locations may be found in Appendix A, Table A1.

4.1.5 Add sight glass tubes to all of the coolant hoses to determine coolant flow direction and level of aeration.

4.1.6 Prepare a production-intent thermostat that can accurately be adjusted for opening between fully open and closed, or four (4) thermostats with fixed openings of approximately 1 mm, 3 mm, 5 mm and full open.

4.1.7 Cycle another production intent thermostat either mechanically or thermally from closed to full open five (5) times. This thermostat will be used for the "**closed thermostat**" tests. Previous experiences with some thermostats suggest that the spring load relaxes after several cycles. This is of importance in inlet-side

thermostats where the spring load may be overcome by the hydraulic pressure differential at high engine speeds. As a result, the thermostat is **"pushed"** open.

4.1.8 If any of the components are electrically powered, install instrumentation to measure the voltage and current supplied.

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.

4.2.2.1 Mount the engine and platform released components on the test fixture.

4.2.2.2 Mount the platform components in relative height to design intent with respect to the water pump centerline.

4.2.2.3 Avoid sharp bends, abrupt transitions, and flow restrictions in the hoses.

4.2.2.4 Remotely mount the water pump for V-engines so that flow meters can be mounted between the pump and block to obtain flow in each leg.

4.2.2.5 Include flow meters in any bypass system (if feasible).

4.2.2.6 Install flow meters in the radiator inlet, radiator outlet, heater inlet, surge tank vent line, and surge tank return line (if applicable), as well as in any other branches of the cooling circuit. For example, a flow meter should be installed in turbocharger bearing cooling lines, if applicable.

4.2.2.7 Fill the system with a 50/50 mixture of dexcool® and water. Be sure to measure the installed volume of coolant.

4.2.2.8 Install the pressure relief cap and introduce coolant into the system (radiator or engine block are good choices) until the system pressure comes up to relief pressure. The pressure cap may be disabled to allow pressure regulation with an external (shop) air source.

4.2.2.9 De-aerate the system.

4.2.2.10 Take pictures of the setup views from various sides to keep records of bench system setup including instrumentations and plumbing details.

4.3 Instructions.

4.3.1 Baseline Run.

4.3.1.1 Heat the coolant to 95 °C. Apply and maintain constant pressure under the relief cap with regulated shop air.

4.3.1.2 Record system data at pump speeds from 500 rpm to maximum pump speed in 500 rpm ± 20 rpm increments for each of the conditions described 4.3.1.2.1 through 4.3.1.2.4.

4.3.1.2.1 Fully open thermostat and apply either 100 kPa or 140 kPa pressure under the surge cap to match the production intent relief pressure.

4.3.1.2.2 Closed thermostat, coolant at 5 °C to 10 °C under the thermostat start-to-open (STO) temperature, and 55 kPa under the surge cap.

4.3.1.2.3 (Optional). Fully open thermostat with coolant at approximately 95 °C and the range of system pressures: 100 kPa, 50 kPa and 0 kPa. This allows an assessment of the system tendency to cavitate under hot ambient conditions.

4.3.1.2.4 (Optional). Obtain thermostats with openings fixed at 1 mm, 3 mm, and 5 mm. Alternatively, prepare a thermostat so that the opening can be changed externally from 1.0 mm to 5.0 mm. Evaluate fixed opening thermostats of approximately 1 mm, 3 mm and 5 mm. Coolant should be at 95 °C and the pressure should be either 100 kPa or 140 kPa under the relief cap.

4.3.1.3 (Optional) Reduced Coolant Level. Repeat 4.3.1.2 with reduced coolant level. Note the status of the low coolant level sensor, if present.

4.3.1.3.1 Install a fully open thermostat. Remove 5.0% of the coolant from the coolant system (round off to the nearest 0.1 L). Use the radiator drain, if equipped. If not, remove the coolant from the surge tank.

4.3.1.3.2 Remove an additional 5% of the coolant from the system (round off to the nearest 0.1 L).

4.4 Service Fill De-aeration (Surge Tank Systems).