



Coolant Joint Pressure Vibration Temperature (PVT) Cycle Test

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. The purpose of this test is to evaluate the sealing capability of engine coolant hose connections and evaluate individual components of the hose connections by subjecting coolant hoses and their attachments to a thermal aging process and a pressure and motion/vibration cycle.

1.2 Applicability. This test is applicable to all vehicles and trucks utilizing glycol/water cooled internal combustion engines.

1.3 Remarks. Not applicable.

2 References

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

2.1 External Standards/Specifications.

None

2.2 GM Standards/Specifications.

GMW14870 (ID) GMW16295

Note: (ID) = This standard is limited to internal distribution within General Motors and shall not be distributed outside this company. Contact the GM Lead Engineer for further instructions.

2.3 Additional References.

- GM Materials and Processes – General, Coolant Hose, Applicable Material Specification, and Interior Cleanliness.
- GM Part Number (PN) 9985809, dexcool® Extended Life Engine Coolant.
- Pressure Vibration Temperature (PVT) User's Manual.
- PVT chamber drawing.
- Test Plan.
- Test Work Order, Activity Request (AR), or equivalent local authorizing documentation.

3 Resources

3.1 Facilities.

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.

3.1.3 A complete Pressure Vibration Temperature (PVT) facility to enclose the coolant joints and related fixturing. The facility will include but is not limited to the following.

3.1.3.1 An environmental chamber capable of maintaining operating temperatures ranging from $-40\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ to $+121\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($-40\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$ to $+250\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$).

3.1.3.2 A motion/vibration inducing system capable of ± 1.27 cm (± 0.5 in) displacement at a frequency of 60 cycles per minute. Displacement capability of up to ± 2.54 cm (± 1.0 in) or more is suggested to support exploratory testing. See Appendix D, Figure D1.

3.1.3.3 A variable displacement coolant circulation pump capable of flowing coolant through the hoses at a rate of 11.3 L/minute to 19.0 L/minute (2.98 gal/minute to 5.0 gal/minute) at room temperature.

3.1.3.4 A pressurization system capable of pressurizing the coolant to 0 kPa, 105 kPa, and 210 kPa with an allowable tolerance of ± 3.44 kPa for each stage (0 psig, 15 psig, and 30 psig with an allowable tolerance for each stage of ± 0.5 psig), at a rate of 8 kPa/s (1 psig/s) at ambient temperature.

3.1.3.5 A coolant heater capable of heating the coolant to a maximum of $+121\text{ }^{\circ}\text{C} \pm 2\text{ }^{\circ}\text{C}$ ($+250\text{ }^{\circ}\text{F} \pm 3\text{ }^{\circ}\text{F}$).

3.1.3.6 An operating system (automatic or manual), with instrumentation, to control the test parameters listed from 3.1.3 thru 3.1.3.5.

3.2 Equipment.

3.2.1 Instrumentation.

No additional instrumentation required unless specified/indicated on Test Work Order (TWO), Activity Request (AR) or Test Plan.

Note: Instrumentation is to be calibrated per laboratory standard practice.

3.2.2 Test Equipment.

3.2.2.1 Torquing Device. A pneumatic or electric torquing tool with microprocessor-based torque/angle controller monitor, having a power rating of 0.25 kW ($\frac{1}{2}$ hp) or less, with free speed not to exceed 350 rpm. Optional: A digital hand torque wrench.

3.2.3 Fixturing. Miscellaneous fixturing, fasteners, manifolds, and other mounting provisions to accommodate the test material.

3.3 Test Vehicle/Test Piece. Test material includes all hoses and attachments required to recreate/simulate in-vehicle installation.

3.3.1 Hoses/Assemblies. Complete hoses or hose assemblies including clamps and/or quick connects. For Validation testing, these shall be certified hoses provided by the hose supplier, unless otherwise specified by the Requesting Engineer. For Development testing, the Requesting Engineer shall specify hose conditions required/allowed.

3.3.2 Attachments. All attaching hardware, including retaining clips, brackets, etc., which constrain hose movement.

3.3.3 Fittings. One set of fittings for each hose/assembly to be tested simultaneously in the chamber, plus one additional set for Installation Force measurement. A set of fittings is comprised of one production fitting (or production representative fitting for each free end of the hose/assembly).

3.3.4 Coolant. To reduce the formation of steam, coolant mixture shall be 85% ethylene glycol per 9985809 and 15% distilled water by volume.

3.3.5 Lubricant. Some fittings may require lubrication, per direction from test requestor. If required, apply lubricant specified by test requestor, approximately six (6) ml per fitting. Record lubricant part number in PVT Daily Test Log (Appendix B, Data Sheet B1).

3.4 Test Time. Times are dependent on the number of samples which can be tested simultaneously. The number of requested samples to test shall match the Reliability Evaluation Point (REP) criteria by GMW16295, the details about the Weibull shall be checked with the GM Validation Engineer, the next duration timing is listed per Part Number (PN) tested:

The following estimates are for a minimum of two (2) samples and maximum of six (6) samples.

Calendar time: 2.5 days (typical per PN).

Test hours: 55.8 h per PN.

Coordination hours: Not applicable.

3.5 Test Required Information.

3.5.1 Test Work Order, Activity Request (AR), or equivalent local authorizing documentation.

3.5.2 Test Log Data, both manual and digital. (Appendix B)

3.5.3 Validation Test and Vehicle Review form. (See Appendix B, Data Sheet B2)

3.5.4 Hose assembly part numbers and installation layouts clearly describing the X, Y, Z mounting locations of all fittings, hoses, clips and brackets, as required. (See Appendix C.)

3.5.5 Test Plan. Provide a plan, including purpose/scope of test, material availability date, required completion date, etc., per local requirements.

3.5.6 PVT User's Manual.

3.6 Personnel/Skills. Not applicable.

4 Procedure

4.1 Preparation.

4.1.1 Documentation. Procure the reference documents specified in 3.5. Record test information and test type, Test Work Order/Activity Request /Task Number, dates, sample part numbers, etc.

4.1.2 Facility Preparation. Procure the test facility as defined in 3.1.

Note: Refer to Test Plan to confirm motion/vibration displacement.

4.1.3 Equipment Preparation. Procure the test equipment, instrumentation, and fixturing described in 3.2.

4.1.4 Test Setup.

4.1.4.1 Review PVT User's Manual for system operation.

4.1.4.2 Number all hose test samples in sequential order and label each joint which is "on test", according to its fitting type, (e.g., engine, radiator, heater, surge tank, etc.) For example: The radiator connection of hose No. 1 would be labeled R1, engine connection E1, etc.

4.1.4.3 Measure fittings, hoses, and installation force, per GMW14870 and document results. This information will be helpful for root cause determination in the event of a leak, blow off or installation effort concern.

4.1.4.4 Install the test sample(s) on the test frame per installation assembly layout, (i.e., orientation of clamps and hoses). Installation of the hoses shall match the in-vehicle mounting dimensions and orientation. Any deviation from the installation assembly layout must be approved by the Requesting Engineer and/or Validation Engineer.

4.1.4.5 Typically, more than one hose assembly is tested in the chamber at the same time. Document the location of each hose assembly, relative to the other hoses in the chamber (i.e., top or bottom, front or rear position). Also, document the position of drip sensors (S1, S2, S3, S4, etc.)

4.1.4.6 If required, torque hose screw clamps to the desired torques (or torque ranges) using one of the tools defined in 3.2.2. Record the torque values obtained. If using a tool requiring rpm monitoring, also record actual tool speed.

Note that constant tension spring band hose clamps do not require any torquing.

4.1.4.7 If alignment marks are not present, create an "index" at the end of each hose after the clamps have been set/torqued. Use a permanent marker to draw a straight line the along the axis of the hose, from the clamp to the end of the hose and onto the fitting. The intent is to provide a reference to determine if the hose moves and how much. Do not use a scribe or any other marking device which could scratch or otherwise damage the surface of the hose or clamp.

4.2 Conditions.

4.2.1 Environmental Conditions.

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.

Deviations from the requirements shall have been agreed upon by the Requesting Engineer and Validation Engineer before starting the test. Deviations shall be specified on component drawings, test certificates, reports, etc.

4.2.2.1 Test Tolerances. Tests shall be conducted under known conditions as defined in 3.1.3, maintaining temperature within ± 1.6 °C (± 3 °F), or according to the design specification requirements.

4.2.2.1.1 Instrumentation shall be calibrated as required. Record date of calibration on facility test data sheet or PVT Daily Test Log.

4.2.2.1.2 Test setup and equipment shall be capable of maintaining test parameters (e.g., load, angles, temperature, etc.) within the limits outlined by the design specifications.

4.2.3 Sample Size. Validation Test – six (6) samples or per Validation Engineer's request.

4.2.4 Performance Objectives. Performance objectives are as provided by the Test Plan.

4.2.5 Test Criteria. The following joint conditions are acceptable:

4.2.5.1 Permissible Hose Movement. Movement of the hose to the point where the clamps are up against the blow off bead, or the actual hose movement is less than that specified by the Validation Engineer and/or as indicated in the Test Plan.

4.2.5.2 Acceptable Leak Rate. See Table 1.

Table 1: PVT Cycle Segments

Segment Number	Temperature Range	PVT Test Criterion for Acceptance
1	-40 °C to -36 °C (-40 °F to -32 °F)	Seepage Acceptable
1	-36 °C to 0 °C (-32 °F to +32 °F)	0 drops
1	0 °C to +121 °C (+32 °F to +250 °F)	0 drops
2	+121 °C (+250 °F)	0 drops
3	+121 °C to +104 °C (+250 °F to +220 °F)	0 drops
4	+104 °C (+220 °F)	0 drops
5	+104 °C to 0 °C (+220 °F to +32 °F)	0 drops
5	0 °C to -36 °C (+32 °F to -32 °F)	0 drops
5	-36 °C to -40 °C (-32 °F to -40 °F)	Seepage Acceptable
6	-40 °C (-40 °F)	Seepage Acceptable
7	-40 °C (-40 °F)	Seepage Acceptable

4.3 Instructions.

4.3.1 Procedure.

4.3.1.1 Prior to testing, visually inspect all hoses for evidence of bloom, cuts/damage or residual oils or other residue from the manufacturing process. Record all observations. Discard any hoses that appear to be damaged and are not good candidates for use.

4.3.1.2 Pressure check the system and setup. Start the system with air regulators set at 105 kPa and 210 kPa (15 psig and 30 psig). An orifice or flow control valve in the main pressure line will allow for the following test pulse profile at ambient conditions:

- System pressure: 0 kPa to 105 kPa (0 psig to 15 psig) in 15 s.
- 105 kPa (15 psig) stabilized for 15 s.
- 105 kPa to 210 kPa (15 psig to 30 psig) in 15 s.
- 210 kPa (30 psig) stabilized for 15 s.
- Total Time: 1 minute.

4.3.1.3 Examine the test setup for any of the following:

- Coolant leakage or seepage: Report pressure setting and amount of leakage (in drops per second).
- Hose movement: Report approximate amount of hose displacement (in millimeters).
- Separation of hose from fitting: Report hose and location where separation occurred.

Note: Flare at hose end due to clamp compression is permissible.

- Any other areas of potential concern.

4.3.1.4 Review pressure check results with Test Engineer.

Note: If any parts are replaced or repaired, the pressure check described in 4.3.1.2 must be repeated.

4.3.1.5 Begin PVT test cycling as follows (see Appendix A, Figure A1 for a graphical representation of the profile).

4.3.1.5.1 Segment 1. 55 minutes – Raise chamber temperature linearly from ambient to 121 °C (250 °F) and stabilize.

- Coolant circulation pump: ON.
- System pressure: PUMP.
- Motion: ± 1.27 cm (± 0.5 in) at 60 cycles per minute.
- Coolant heater: ON.

4.3.1.5.2 Segment 2. 89 minutes – Maintain chamber temperature at 121 °C (250 °F) while pressure cycling at 210 kPa (30 psig) for 0.5 minute and 105 kPa (15 psig) for 0.5 minute.

- Coolant circulation pump: ON.
- System pressure: 210 kPa and 105 kPa (30 psig and 15 psig).
- Motion: ± 1.27 cm (± 0.5 in) at 60 cycles per minute.
- Coolant heater: ON increasing coolant temperature linearly to 120 °C and stabilize.

4.3.1.5.3 Segment 3. 25 minutes – Reduce chamber temperature linearly from +121 °C to +104 °C (+250 °F to +220 °F) and stabilize.

- Coolant circulation pump: ON.
- System pressure: PUMP.
- Motion: ± 1.27 cm (± 0.5 in) at 60 cycles per minute.
- Coolant heater: OFF.

4.3.1.5.4 Segment 4. 30 minutes – Maintain chamber at +104 °C (+220 °F) while pressure cycling at 105 kPa (15 psig) for 0.5 minute and 0 kPa (0 psig) for 0.5 minute.

- Coolant circulation pump: ON.
- System pressure: 105 kPa and 0 kPa (15 psig and 0 psig).
- Motion: ± 1.27 cm (0.5 in) at 60 cycles per minute.
- Coolant heater: OFF.

4.3.1.5.5 Segment 5. 110 minutes – Reduce chamber temperature linearly from +104 °C to -40 °C (+220 °F to -40 °F) and stabilize.

- Coolant circulation pump: OFF.
- System pressure: 105 kPa (15 psig).
- Motion: OFF.
- Coolant heater: OFF.

4.3.1.5.6 Segment 6. 55 minutes – Maintain chamber at -40 °C (-40 °F).

- Coolant circulation pump: OFF.
- System pressure: 10 kPa (15 psig).
- Motion: OFF.
- Coolant heater: OFF.

Note: Soak period will be dependent upon ramp rate of Segment 5.

4.3.1.5.7. Segment 7. 30 minutes – Maintain chamber at -40 °C (-40 °F).

- Coolant circulation pump: ON.
- System pressure: 105 kPa and 0 kPa (15 psig and 0 psig).
- Motion: ± 1.27 cm (± 0.5 in) at 60 cycles per minute.
- Coolant heater: ON increasing coolant temperature to 100 °C and stabilize.

4.3.1.5.7.1 Monitor test and visually inspect for leakage, hose movement, or any other abnormalities, and record observations on the PVT Daily Test Log (Appendix B, Data Sheet B1).

4.3.1.5.7.2 Return to "Segment 1" (4.3.1.5.1) for start of next cycle (Table A1).

4.3.1.6 Repeat 4.3.1.5 based on type of test specified in Test Plan, e.g., Validation Test = 10 cycles total.

4.3.1.7 After the last test cycle has been completed, or at any other intervals as described in the Test Plan, measure hose samples as specified in the Test Plan, and record findings.

4.3.1.8 After completion of all segments, and when test samples and chamber have stabilized to room temperature, measure and document clamp diameters and hose movement. Disassemble hoses from mating fittings, and record all subjective observations regarding ease of hose removal/hose retention to fitting.

5 Data

5.1 Calculations. Not applicable.

5.2 Interpretation of Results. Not applicable.

5.3 Test Documentation. Record information on computer test Data Sheets (See Appendix B, Data Sheets B1 and B2).

Note: Test data is to be considered GM Confidential. Data can only be released by Fastener or Design Engineer.

5.3.1 Certified Hose: Vendor to provide the following documentation for each hose: Hose inside diameter, hose outside diameter, wall thickness, durometer reading, rubber compound and type of cure, and procedure on their detergent wash cycle.

Reference GM Materials and Processes – General, Coolant Hose, Applicable Material Specification, and Interior Cleanliness. "Inside surfaces of hose (as received) shall be free of any soap, soapstone, talc or other substance, including silicone, which could interfere with attaining a satisfactory clamping load or which could act as a lubricant resulting in unsatisfactory retention on fittings."

As part of the certification process, the hose manufacturer will indicate, in writing, that the hose Inside Diameter (ID) is free of the aforementioned substances (including bloom) and that there is nothing to interfere with obtaining satisfactory clamping load.

6 Safety

This standard may involve hazardous materials, operations, and equipment. This standard does not propose to address all the safety problems associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

7 Notes

7.1 Glossary.

Bloom: A discoloration or change in appearance of the surface of a rubber product caused by the migration of a liquid or solid to the surface. Examples: Sulfur bloom, wax bloom.

Installation Force (N): Reference GMW14870. **Note:** References to torque in this procedure always refer to dynamic torque.

Joint Adhesion: Subjective rating by technician on adhesion of test hose to fitting, e.g., 0 = Poor, 5 = Good.

Note: Rating is done at the end of the PVT test and is recorded at the bottom of the PVT Daily Test Log.

Seepage: Observation on the amount of coolant that spreads or permeates at hose/fitting interface. See Appendix E, Figure E1.

Segment: One (1) of the seven phases of the PVT environmental cycling profile.

Validation Test: Runs a fixed number of 10 cycles and will always use the VALIDATION procedure file.

Zone: A physical location within the environmental chamber, e.g., for PVT No. 2 chamber there is a front, middle, and rear zone. For zone locations, reference PVT chamber drawing.