Thermal Cycling Test for Life Assessment of Powertrain Sealing Systems

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.

Note: The words must, shall, or will as used in this document means a mandatory requirement.

Note: In the event of conflicts between the content/intent of this document and a certified laboratory version, this and only this document shall take precedence. Discipline regarding this test and its execution will be maintained and enforced if necessary, with removal of certification if violations occur.

Note: Specifics as to what is considered a GMW3155 test, are listed in Appendix A, A4.

Note: No one involved in GMW3155 testing is to make judgments or interpretations as to content/intent of this document and take independent action as a result. All procedural issues (including deviations) are to be immediately brought to the timely attention of the document sponsor and the GM Global Sealing Technical Specialist **before the event is reached**. Our intent is to drive continuous improvement of document content and not risk voiding a test, due to unauthorized deviations. Any tested procedural step or content conducted in a test (without one (1) time approval) and is not covered in the latest written version of GMW3155 [including Criteria for Thermal Cycling Test for Life Assessment of Powertrain Sealing Systems (see GMW3155)], is prohibited.

1.1 Purpose.

1.1.1 This test is used to predict the life of powertrain sealing as it applies to the intended system design. The system includes the gasket, fasteners, structural interfaces, and circulating media.

1.1.2 This test is used on components and assemblies (up to entire engines and transmissions) to identify and eliminate marginal seal designs and/or materials. Design has a significant influence on test results. Production released or production intent parts shall be used.

1.1.3 GMW3155 Use Restrictions. Requiring a supplier to have GMW3155 capability internally as a requirement for contact business is strictly prohibited. Logistically, it is impossible to certify all global sealing related suppliers. Candidate selection is carefully planned and controlled for testing consistency, business, and confidentiality reasons.

1.1.4 Management and Certification. GMW3155 is managed by General Motors Global Propulsion Systems (GM GPS) Headquarters. Certification to run GMW3155 is obtained only through the application and certification approval process. See 3.1.3.

1.1.5 What Is GMW3155 Certification? To better understand the process and if your facility might be a candidate, one can request a copy of this document from the GM GPS Engine Materials Engineering Department.

1.2 Applicability.

1.2.1 This test is suited to the evaluation of all static powertrain gaskets and seals that experience thermal cycling during service. It is based on European and North American passenger vehicle and light duty truck applications. Other regional or vehicle applications, e.g., Heavy Duty (HD) trucks, may not experience the thermal cycle described in this standard.

1.2.2 This test permits the optional use of mechanical devices to impart motion or load on any test fixture(s).

1.2.3 High temperature applications (e.g., head, exhaust, turbo), or Exhaust Gas Recirculation (EGR) gaskets, are beyond the limits of this test.

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1.2.4 Test Oils. The test fluid circulatory system of each test unit shall permit steady and progressive oxidative degradation of the test oil to End of Test (EOT). Fluid degradation is measured using the appropriate fluid industry tests listed in 3.3.1.7. With no blow-by or Positive Crankcase Ventilation (PCV) recirculation provisions, this test does not replicate oil degradation under engine operating conditions.

1.2.5 Fluid Leak Requirements. All tested samples for validation have one (1) sealing performance requirement defined in a restricted General Motors Worldwide (GMW) document and supercedes all previous and existing statements. Any no leak criteria for evaluation during or after GMW3155, must be defined and/or have measurable values listed on the print, advance development and validation plan, and/or the Performance and Quality Management System (PQMS) test request.

1.2.5.1 High Fluid Pressure Fixture Integrity Leak Check at Start of Test (SOT) and EOT. For all liquid connections and evaluated joints a short fluid pressure check is required to determine fluid integrity. The default test time to measure the sealing integrity is 2 minutes. Repeat the high fluid pressure at EOT. No fluid leakage shall occur as defined by the latest written version of GMW3155 including Criteria for Thermal Cycling Test for Life Assessment of Powertrain Sealing Systems GMW3155.

1.2.5.1.1 For high pressure coolant joints, apply the maximum fluid pressure as supplied by the component Design Responsible Engineer (DRE) or supplier.

1.2.5.1.2 For high pressure engine oil joints (non-spray bar), apply the apply 1400 ± 100 kPa (14 ± 1 bar or 203 ± 15 psi) pressure for 5 seconds of oil circulation.

1.2.6 Air Leak Requirements – Fluid Spray Joints Only. All tested samples for validation have media specific sealing performance requirements defined in a restricted GMW document and supercedes all previous and existing statements. Other no leak criteria for evaluation during or after GMW3155, must be defined and/or have measurable specified values listed on the print, advance development, and validation plan and/or the PQMS test request.

- For oil joints operating under atmospheric conditions, unless otherwise specified, the air leak default test condition is 2 minutes at 14 kPa (-0.3 kPa, +0 kPa) with no leak detected at SOT, each of the designated frequency intervals and at EOT.

1.2.6.1 Purpose of Air Leak Testing Fluid Spray Joints. Test fixture leak integrity at the specified test intervals is measured with air because fluid media spray patterns are not always 100% effective in properly distributing fluid to the evaluated joint. All evaluated fluid joints must pass air at the minimum default condition per 1.2.6 (no exceptions).

1.2.7 Test Fixture Limit Testing. Fixtures shall be at Least Material Condition (LMC) (3.3.4) at the lowest torque. Maximum material condition testing is optional. See 3.3.2.2.4.

1.3 Remarks. This standard describes the methods for evaluating sealing systems in their intended subsystem assembly using engine oil, transmission fluid, coolant, or air as a circulating medium. Test fixtures are cycled through hot and cold temperature extremes for approximately 12 weeks to 18 weeks continuously (24 h/day, 7 days/week). The performance measure is determined by test completion without unacceptable leakage (successful test).

1.3.1 Media Cycles. For each liquid testing medium, there is a thermal test cycle. Table 3 is for Air, Table 4 is for Engine Oil/Transmission Fluid and Table 5 is for Engine Coolant.

1.3.2 Before **initially** running, and at the end of the selected test procedure, the following tests are required:

- **GMW3137 Dynamic Sealing Stress Measurement for Powertrain Sealing Systems.** A method for measuring continuous stress distribution between the gasket and joint surfaces using an electronic sensor film. Films are capable to 200 °C continuous, permitting the sensor to be left in the joint during testing for select data capture at desired test intervals. This is optional if GMW3152 is used.
- **GMW3149 Air Leak Testing for Leak Rate Determination of Powertrain Sealing Systems**. This test establishes if the test fixtures and test joints have been sufficiently sealed prior to the SOT, and any leak path has been created at EOT.
- **GMW3152 Static Sealing Pressure Measurement for Powertrain Sealing Systems.** Commonly referred to as a Fuji Paper (www.fujifilmusa.com) test, it measures the initial contact sealing pressure distribution achieved in the test joint using contact pressure sensitive color developing film. Measurement during initial

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assembly confirms if the seal to joint contact is continuous and sufficient to survive the test. It may also be used as a diagnostic tool for leaking parts at EOT.

1.3.3 Fluid Exposure. Fluid exposure to evaluate hydraulic fluid joint sealing is by:

a. Spray bar only to cascade oil over the evaluated joints. All test fluid is effectively drained during non-circulation periods.

b. Spray bar and direct fluid contact as intended in the joint(s) under evaluation at pressure. A desired fluid level is maintained during non-circulation periods. The retained fluid in the fixture is agitated during circulation periods using an immersed agitation tube pumping the same test fluid.

c. Agitation bar only fully submersed in desired test fluid level.

d. Coolant joints are only evaluated by direct contact at pressure (no spray or agitation bar).

2 References

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

2.1 External Standards/Specifications.

ASTM A109	ASTM D97-17a	ASTM D4684-17	QQ-S-698

2.2 GM Standards/Specifications.

9985522	GMW3137	GMW3152	GMW16676
9986153	GMW3149	GMW3420	GMW17332
9986333			

2.3 Additional References.

- Allen-Bradley, Rockwell Automation Incorporated, Milwaukee, Wisconsin, www.rockwellautomation.com.
- Build Assembly Documents.
- Customer Care and Aftersales (CCA), 6200 Grand Pointe Dr., Grand Blanc, MI 48439.
- Emerson Electric, St. Louis, Missouri, www.emerson.com, (Chromalox heaters).
- Fujifilm Holdings America Corporation, North Kingstown, Rhode Island, www.fujifilmusa.com.
- GM Powertrain Contract Review Form.
- McMaster Carr, Elmhurst, Illinois, www.mcmaster.com.
- Omega Engineering, Incorporated, Stamford, Connecticut, www.omega.com.
- Performance and Quality Management System Test Request.
- SK Holdings Corporation, Seoul, Korea, www.sk.com.

3 Resources

3.1 Facilities. Only GM GPS or designated approved laboratories are qualified to run GMW3155 durability test schedules. Certificates are issued every 4 years, listing the qualified site tests and their approved media. First time candidates are added upon successful completion of blind sample testing with a qualified GM site. Certificate renewal is required to keep a test facility approved. Laboratories or equipment changing location during their certification period, shall be reviewed for compliance. A new system or replacement of chamber, heater, or reservoir to a test setup must be certified by qualified GM personnel.

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.

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3.1.3 Applying for Certification. Under no circumstances are decisions to launch new GMW3155 test facility locations to be undertaken without knowledge and previous approval from the Global Sealing Technical Specialist and the GM GPS certification personnel. A request form (obtained from certification personnel in Engine Materials Engineering), to initiate this process must be filled out and submitted to the laboratory certification personnel for review and signature (if approved). Activities conducted without written approval first, will not be certified.

3.1.4 A suitable area or room for conducting testing with a stable and conditioned environment.

3.2 Equipment.

3.2.1 Basic. Equipment information is supplied to laboratories at the beginning of the certification process when their initial request for certification is approved by the Global Sealing Technical Specialist and the certification team. Equipment requirements are often updated due to changes in test requirements over time. Do not rely on previous versions of this standard where equipment was detailed as past equipment content no longer complies with current document requirements. Following the latest supplied equipment list avoids money wasted on the wrong items, and speeds up the certification approval.

3.3 Test Vehicle/Test Piece.

3.3.1 Test Media.

3.3.1.1 The chosen test engine oil must have a -35 °C low temperature flow in MPa/s per ASTM D4684-17 as defined in multiple GMW oil standards (see Table 1, Test Media) to prevent chamber line plugging and oil starvation. Any GM Dexos® approved 0W20 source may be used provided the oil pour point to ASTM D97-17a, or equivalent method is -40 °C or colder. Document revisions to Table 1 may not keep pace with fluid or specification changes. Before starting any test, contact the design responsible engineer, test laboratory and/or fluids material engineer to verify the correct current test media. GMW3155 tests using oil grades (outside GM Dexos® approved 0W20) must be classified as test fluid modified GMW3155, no correlation to design life (see Appendix A, A4.8*).*

3.3.1.2 Before starting any test, purge used test fluid completely from the circulation system. Flush the system (approximately 56.78 L (15 gal) for hydraulic fluids) with fresh fluid, the same as the test fluid, and drain as completely as possible. Recharge with fresh test fluid. Supply and return fluid lines, fixture layout and design shall promote complete drainage.

3.3.1.3 Recording Amount of Test Fluid. Measure and record (following the completion of 3.3.1.4), the initial room temperature volume (milliliters) of the total test fluid used to charge the whole circulation system (including, if applicable, any resident fluid retained in each test fixture). This is required as part of the laboratory qualification testing for Phase 1 and Phase 2.

3.3.1.4 Adding and Replacing Test Fluids. Within the first 50 test hours, fresh fluid may be added to compensate for a drop-in fluid level from the purging of entrapped air in the plumbing system, etc., with any fluid system. After 50 test hours, no further additions of test fluid shall be made for oil and Automatic Transmission Fluid (ATF) systems, except as noted in 4.3.1.7. Addition of fluid in coolant systems is permitted throughout the test to maintain coolant concentration as stipulated in 3.3.1.9 and 4.3.1.7. Record the added fluid(s) and add it to 3.3.1.3 number.

3.3.1.5 Ultraviolet (UV) Dye Oil. See When to Use Dye, 4.3.1.3.3. Add appropriate dye to test fluid for UV inspection. As oil is changed, new dye must be added, but only as required per 4.3.1.3.3. Commercial dyes vary in concentration, so adjust the amount used to achieve the desired response with the UV light output. Customer Care and Aftersales, North America, use Dye-Lite TP-3400 IR or Dye-Lite TP-3400 (6200 Grand Pointe Dr., Grand Blanc, Michigan 48439) for oil and oil-based fluids. The instructions will provide the suggested dilution ratio:

- Gasoline engine oil 14.8 mL per 3.78 L to 5.76 L (0.5 oz per 4 qt to 6 qt)
- Diesel engine oil 14.8 mL per 3.78 L (0.5 oz per 4 qt)
- Automatic transmission fluid 29.6 mL per 11.35 L (1 oz per 12 qt)

Note: If the oil is very dirty, more dye may need to be added to obtain a good fluorescent response (additional dye will not harm the engine).

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3.3.1.5.1 Coolant UV Dye. Add appropriate dye to the test fluid for UV inspection. Commercial dyes vary in concentration, so adjust the amount used to achieve the desired response with the UV light output. The GM Component Test Laboratory (CTL) uses Tracer Products Dye-Lite TP-3940-0601.

3.3.1.6 Laboratory Qualification Oil Samples. In Phase1 (laboratory attempting to qualify for validation certification), take 100 mL samples at 0 h, 81 h, 162 h, 243 h, 486 h and 792 h of circulation. Take two (2), 200 mL samples at EOT (1000 h). No samples are required after 1000 h. Submit oil to the Fluids and Lubricants Group of GM GPS Materials Engineering. In Phase 2, where a common test fixture is evaluated between the qualifying laboratory and the GM CTL, both laboratories must use test fluid from the same drum and submit oil to these intervals.

3.3.1.6.1 Validation Oil Samples (Certified Laboratories). For each test, take 100 mL samples at 0 h, 486 h and 1000 h. After sufficient data history, qualified GM personnel may grant (in writing) to approved test laboratories, a once per year random test fluid analysis requirement. Each reduction approval is specific to a test chamber/fluid and cannot be transferred.

3.3.1.6.2 Test Oil Retention (Certified Laboratories). Retain 100 mL samples at 0 h, 486 h and 1000 h for 90 days beyond the date the last sample was taken for every GM test. The retained containers are stored away from any light source. Do not run any oil analysis unless directed by the GM DRE. If no analysis is requested by 90 days, dispose of the used test oil in the appropriate manner.

3.3.1.6.3 Oil Samples (Certified Laboratories). For every fifth (5th) GM fixture test, take 100 mL samples at 0 h, 486 h and 1000 h. After sufficient data history, qualified GM personnel may grant (in writing) to approved test laboratories, a once per year random test fluid analysis requirement. Each reduction approval is specific to a test chamber/fluid and cannot be transferred.

3.3.1.7 Oil Analysis Tests. Samples must be submitted to GM GPS Headquarters engine oil material's engineer for analysis (the certification personnel will identify the contact person and shipping address to receive the oil). Currently there are no international shipping restrictions for oil provided it has no residual fuel. Since no fuel is used in GMW3155 because of safety concerns the used oil is safe to transport.

3.3.1.8 Oil test data (see 3.3.1.6 and 3.3.1.6.1), shall be within established limits for each test. Approval to run validation is based on comparative results between GM GPS and the candidate laboratory on identical test media, fixtures, and conditions. Contact GM GPS Materials Engineering Fuels and Lubricants Group for test limits.

3.3.1.9 Coolant Concentration. Use a refractometer to monitor the required coolant/water mix ratio (50/50) percent (%) volume for North American engines. See Table 1. Addition of coolant and/or potable water is permitted during the test to maintain the nominal concentration within (5%). Check coolant concentration once per week (Monday through Friday) and record the results in the daily log.

3.3.2 Test Preparation.

3.3.2.1 Inspect Test Parts. Check for defects such as nicks, cuts, cracks, excess material, poorly machined surfaces, etc. Notify test requester of all defects so that the test part(s) can be approved for use or replaced.

3.3.2.2 Responsibilities of Requester for Validation Test. The test requester must gather the subject production intent components and verify compliance to the design specifications or part prints, and utilize all appropriate components that are part of the gasket/seal joint being analyzed, (see 3.3.2.2.1 through 3.3.2.2.3).

3.3.2.2.1 Production intent materials (e.g., the elastomer production compound number), components and assemblies.

3.3.2.2.2 Production intent fastening specifications and tightening sequence.

3.3.2.2.3 All Production release hardware attachment to a component or part (e.g., coil packs, brackets, etc.)

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Table 1: Test Media

Global Region	Test Media Note 1	Test	Type	Change Interval Note 2
All	Ultraviolet Dye meeting 9985522	Oil	See 3.3.1.5 and 3.3.1.5.1	As required (see 4.3.1.3.3)
	Extended Life Coolant	Coolant	GMW3420, (50/50) percent (%) volume mix with potable water	End of Test
	Air	Air	Filtered	Not applicable
Gas and Diesel				
All	**GMW17332**	Oil	0W-40 (Dexos® 2) 0W-20 (Dexos® 1)	End of Test
Transmission				
All	**9986153**	Automatic transmission (ATF)	Dexron®VI Note 3 (SK Energy ATF - Korea)	End of Test
All	**9986333**	ATF	Dexron®VI Note 3 (ATF – 212B)	End of Test

Note 1: Unless otherwise specified, the default fluid is in **bold**. Test oils are selected using the lowest fluidity temperature (pour point), not cold cranking temperature.
Note 2: Change intervals are based on fluid additive degradation and circulating equipment limitations. They are **not** correlated to customer service intervals.
Note 3: Dexron® is the GM trademark for their transmission fluids. Transmission Design Release Engineers follow the Statement of Requirements (SOR) fluid requirement for the specific transmission.

3.3.2.2.4 Testing to Dimensional Tolerance. Indicate the tolerance conditions for the test samples. If only one (1) sample or fixture is tested, use the limit that provides the lowest gasket load and fastener torque, (see 1.2.7 and Appendix A, A3.2). Compliance to GM design life cannot be satisfied testing to nominal or as-received condition components for a single test. GM acknowledges that due to gasket, component material and joint construction, not all joints can be tested in a least material tolerance condition using the described appendix shim method. The test technician, the design responsible release engineer and if required, the GM Global Sealing Technical Specialist, make the determination if a joint cannot be properly dimensionally toleranced. Under these circumstances, a gasket cannot be classified as meeting design life by this test and must be identified as an approved deviation, meeting sealing warranty. Joints that can be tested to LMC, are not exempt under these rules (see Appendix A, A3). All elements of the test fixture must meet print dimensions before they are shipped. Checking the received parts dimensionally by laboratory personnel is also recommended, but may not be possible with black box components.

3.3.2.2.5 Preferred location of fixture thermocouple and special media conditions (e.g., pressure).

3.3.2.2.6 The DRE or test requester must authorize in written form, a deviation for questionable assemblies to maintain integrity of validation test status before the SOT. (see 3.3.2.2.4 and 4.3.1.1).

3.3.2.2.7 Test duration if longer than 1000 h for oil or 1620 h for coolant.

3.3.2.2.7.1 Test Duration Requirements as Part of Assembly (POA) or Direct Purchase. For tests on fixtures or samples which are contracted by supplier to an approved test laboratory outside GM, it is the responsibility of the test requester to confirm the required test hours from the GM release responsible engineer for that item or the GM GPS Sealing Technical Specialist. The test may start without this information, but a decision must be made before the 3.4.2 test times are reached. A letter or electronic mail record confirming this agreement shall be part of the test report submission.

3.3.2.2.8 The test technician shall configure the spray/aeration bar(s) so long as they produce the desired effect on the tested joint to the requirements of 1.3.3, 3.3.4.1.3, and 3.3.4.1.5.3. The final GMW3155 report shall indicate the spray pattern satisfied 3.3.2.2.8. Confirmation that the spray bar and pattern meets 3.3.2.2.8, is

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communicated to and confirmed by the DRE or test requester before the SOT by the fixture assigned test technician.

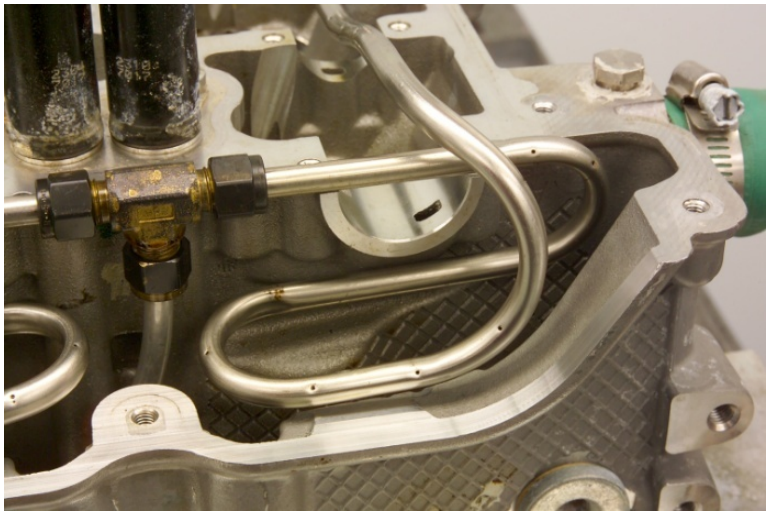
3.3.2.3 Part Cleanliness. All test parts must be clean to production intent requirements, unless otherwise specified between tester and requester.

3.3.3 Equipment Preparation. Check instrumentation calibration and machine maintenance as required by the local standard laboratory operating procedures. A frequency must exist consistent with use, with higher rates requiring more frequent checks.

3.3.4 Test Fixture Preparation. Preassembled fixtures (including whole engines) for all media, will be accepted from any source, provided they were assembled under GMW requirements. Appendix A, A3 lists the essential elements and direction of the test requester. Fixture approval including the intended tolerance LMC and surface finish considerations on the evaluated joints, must be confirmed by electronic mail or facsimile (cannot be verbal) from the DRE and/or GM Global Sealing Technical Specialist to the approved test facility before testing is started. The fixture approval confirmation is included in the final test report.

3.3.4.1 Oil/ATF Systems. All hydraulic fluid joints are tested using spray or agitation bars (see 1.3.3). Fabricate fixture and/or subassembly to simulate application fluid exposure environment. For most oil system tests, spray bars are fabricated to spray test fluid at the seal interface while under test (see Figure 1). Do not submerge joint interface.

Figure 1: Spray Bar – Three (3) Dimensional Configuration



3.3.4.1.1 Oil/ATF Pressure. For spray bar systems, 35 kPa to 70 kPa (5 psi to 10 psi) supply line pressure (measured at fluid inlet to fixture) usually provides sufficient spray patterns for oil, depending on the number of fixtures in the circuit. Internal cavity pressure will aid drainage, but it should not exceed 14 kPa (2 psi) unless otherwise agreed to by test requester. Each fixture must have sufficient drainage to prevent fluid from filling the fixture over the joint interface, unless agreed to by the test requester.

3.3.4.1.2 High Pressure Oil (No Spray Bar). Some joints require closed flow circuits and high pressure flow (e.g., oil filter adapter, oil gallery, etc.) without a spray bar. A pressure restrictor may be used to create pressure required in the component. For gaskets with localized high pressure ports, testing is conducted with separate variable speed pump and pressure delivery fixtures. Requirements for all gas and diesel engines regarding the component environment are 1400 ± 100 kPa (14 ± 1 bar or 203 ± 15 psi) oil pressure for the first 5 seconds of oil circulation which occurs immediately following the daily cold soaks at -18 °C and the weekend cold soak at -40 °C. After the first initial impulse pressure and during the remaining oil circulation period, the pressure should be maintained at steady state at 800 ± 100 kPa (8 ± 1 bar or 116 ± 15 psi). This is a programmable event applied within 2 minutes of the start of the temperature transition/ramp. This step is skipped at initial start of test only (see Table 4).

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3.3.4.1.3 Spray Bar. Form spray bars from 6.35 mm (0.25 in) or 7.94 mm (0.31 in) inside diameter aluminum or steel (without copper) tubing following the desired spray exposure pattern. Other tube sizes may be used, provided all requirements for spray characteristics as specified in this procedure are met. Use tube benders as needed to avoid kinks or wrinkles at curved bends. Decide on the fixed distance the tubing will be from inside the sealed joint during testing, before tube forming. Spray bars must follow the evaluated joint contour delivering fluid uniformly along the entire sealing interface. A recessed port or hole may use a single tower with a modification delivering a circular spray pattern (see Step Note in 3.3.4.1.3.1). The test requester must review and approve the spray bar and pattern before SOT. This review and approval will be entered into the test record.

3.3.4.1.3.1 Spray Aim. Once tube loop is formed to the desired position, follow **Step 1** and **Step 2**:

Step 1. Use Table 2 to determine the number of holes required for a tube inner diameter (ID), to maintain a proper spray pressure and pattern for normal (3.3.4.1.1) and high pressure (3.3.4.1.2) testing.

Table 2: Holes per Spray Bar Tubing Size

Nominal Size, Millimeters (in)	**Tube Identification, Millimeters** (in)	**Circular Area, Squared Millimeters** (in^2)	**Maximum Holes for Total Bar Length,** (22 mm spacing)
6 × 2 (0.25)	4 (0.178)	12.57 (0.0249)	21
8 × 2 (0.3125)	6 (0.24)	28.27 (0.0452)	38
10 × 2 (0.375)	8 (0.304)	50.26 (0.0726)	60
12 × 2 (0.5)	10 (0.402)	78.54 (0.1269)	105
Army-Navy Sizes (AN) (U.S.)			
AN-6	(0.29)	(0.0661)	55
AN-8	(0.392)	(0.1207)	99
AN-10	(0.482)	(0.1825)	150
AN-12	(0.608)	(0.2903)	239
AN-16	(0.84)	(0.5542)	455

Note: AN = Army-Navy.

Step 2: Drill 1 mm (0.04 in) holes spaced 22 mm ± 1 mm (0.79 in ± 0.04 in) apart around the perimeter, and oriented so that the fluid will spray over the joint approximately 12 mm (0.50 in), and flow down across the interface on horizontal joints.

Note: For vertical joints (i.e., Front Covers and Rear Covers, see Figure 2), the test requester must specify the desired spray pattern and aim.

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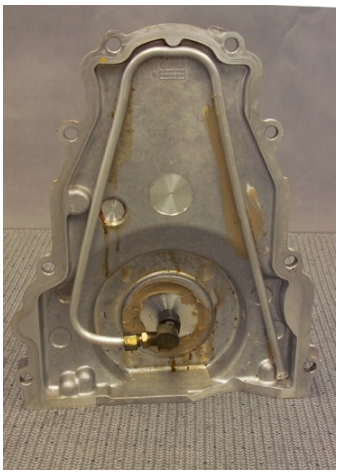
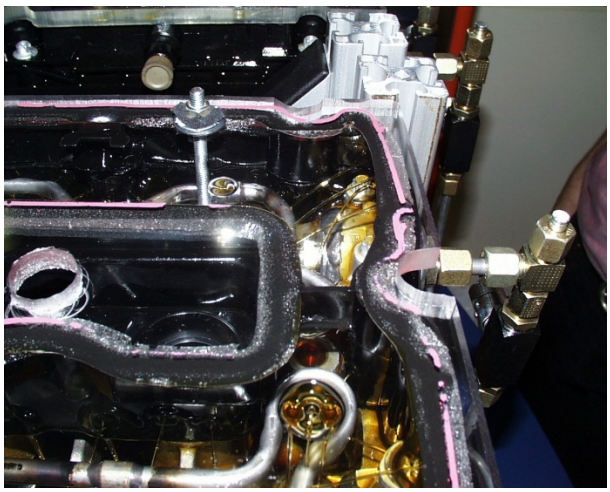
Figure 2: Vertical Front Cover - Vertical Two (2) Dimensional



3.3.4.1.3.2 Spray Bar Attachment. Secure the spray bar loop in the fixture, using metal straps or other means to keep it stable for the duration of the test. The attachments (straps) must not interfere with the fluid spray.

3.3.4.1.3.3 Spray Verification. Place a cover with a view opening or a transparent material cover on the joint; or place open fixture in a suitable viewing enclosure, to observe the spray pattern (see Figure 3). Make adjustments to the pump pressure or speed (flow) to get the proper fluid spray pattern. Set the spray pattern controls using heated oil. The operator has the option to verify fluid spray coverage by allowing the fixture(s) to frost over after the first cold soak, then starting the circulator to observe the defrosted pattern. The elevated spray bar pattern must be over the evaluated joint (not impinging fluid directly on the joint) and residual fluid level, cascading oil downward by gravity across the interface on horizontal joints (see 1.3.3).

Figure 3: Oil Spray Pattern under Plastic



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3.3.4.1.4 Supply and Return Lines - Oil/ATF. Fluid inlet and outlet paths are typically formed using tee connectors and compression fittings. Select an outlet location to achieve maximum fluid drainage (see Figure 1). The drain fittings and line inside diameters, are typically 18 mm (0.75 in) minimum for engine and large component fixtures. The drainage system must be sufficient to avoid fluid pressure spikes, fluid buildup, or deviations in internal cavity pressure outside stated limits in any test fixture(s). Set up drain lines to drain completely when fluid flow is shut off before cold cycle. This prevents pressure buildup on startup due to cold oil in drain lines. Rely on gravity flow from each fixture to the reservoir. If this cannot be guaranteed due to the geometries of the fixtures, an additional drain pump may be used. In this case, balance of feed and drain pump together with a ventilation system must keep fixture cavity pressure within stated limits. Use compression and flare fittings for all connections and steel braided/Teflon core lines for fluid supply and return lines whenever possible.

3.3.4.1.5 Test Fixture Sealing and Installation - Oil/ATF Systems. Seal the fixtures (block off all external paths to the atmosphere to create an air tight assembly) so only fluid inlet and outlet are open (see Figure 2). Use Room Temperature Vulcanizing (RTV) sealants or anaerobic compatible with Table 1 fluids. If RTV sealant is used in an evaluated joint, the minimum sealant cure time is 72 h in air, with laboratory conditions at > 30% Relative Humidity (RH) or longer, for the product to seal until SOT. The sealant must be robotically applied, except in select areas where manual is the only practical alternative. The minimum product and surface temperature at time of sealant application shall be 18 °C or higher. All RTV sealant joints must be closed and clamped within 8 minutes of the sealant applied to the flange. Clamped is defined as having 100% of the fasteners tightened to the final torque.

All bulk chemical products used in evaluated joints shall be recorded and reported in the final test report. Record source, product, and lot numbers and use before date. Do not use product that has no storage and/or use before date records. Product traceability is necessary in the event of a leak before EOT.

3.3.4.1.5.1 Install fabricated components or assemblies in the test chamber in the designated orientation that provides a uniform media temperature, pressure and/or flow at each fixture entry point.

3.3.4.1.5.2 Locate and position all fill and drain lines to achieve complete test fluid drainage to the reservoir. For reference, a sight glass can be installed to verify a full drain reservoir fluid level.

3.3.4.1.5.3 Agitation Bar Fixturing for Immersed Joints. Install an agitation bar(s) under the oil/ATF surface to provide agitation and aeration during circulation hours. The spray bar pattern depends on the orientation and size of the immersed area. Unlike the stricter orientation and location requirements for cascade oil flow (see 3.3.4.1.3.3), some freedom is permitted in the size and placement of the immersed spray bar(s). At circulation startup from low temperature condition, the residual retained test fluid must not prevent/interfere the fixture fluid inlet temperature from reaching the required temperature limit in 30 minutes or less (see 4.3.1.4), nor any fluid pressure imbalance (see 3.3.4.3).

3.3.4.1.6 Surrogate Fixtures. Use a machined base test plate where the mating component is not available or the surface finish effects on sealing require evaluation. During machining, dimensional tolerance to the LMC might be possible without shimming the bolt locations. This must be checked and approved by the DRE. GM GPS recognizes that surrogate joints are the only time the production intent print maximum surface finish (worst case) on half of the joint is part of the sealing performance evaluation. Available test components including whole engines, represent only the as received production process finish. Available component finished axial loaded seals are tested at LMC by shimming (Appendix A, A3). To represent worst case with radial loaded seals (e.g., a switch or sensor pressed into bored engine hole) where dimensions and finish are predetermined, the bore must be machined to the maximum tolerance and finish limits allowed by the production drawings (Appendix A, A3.2).

3.3.4.2 Coolant Systems. Fabricate fixture to simulate the application fluid exposure environment. In most cases a closed/pressurized circuit, utilizing actual coolant reservoir bottles or expansion tanks, will be made for coolant tests. See Appendix A, A2.

3.3.4.2.1 Coolant Pressure. Typically, coolant systems are closed circuits with pressurized coolant circulating. A 100 kPa to 205 kPa (15 psi to 30 psi) supply line pressure (measured at fluid inlet to fixture) is usually sufficient for realistic flow duplication, depending on the number of fixtures in the circuit. At the current 50 v/50 v mix of coolant and potable water, to prevent vaporization in the return lines, a 1.7 bar minimum line pressure must be maintained. The test requester shall specify the desired coolant test pressure if the component conditions require it, but it shall not be below 1.7 bar.

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